Performance and motor control of fundamental skills

Part I: Prehension
PREHENSION

- Act of reaching and grasping which includes the approach (reach), grasp, and releasing the object.

- Prehension is different from the action of reaching and pointing to an object (aiming skill)
Motor Development Perspective

• Very important skill that enables the infant to interact with their environment because it involves manipulation of objects
• Baby’s initial attempt to reach, grasp, and manipulate an object is an extremely important sign of motor development
• First sign of voluntary reach and grasp is around 4 months of age
• The reach and grasp seem to appear simultaneously
Prehension: Motor Control View

Prehension has three components:

- reach,
- grasp, and
- object manipulation

Prehension is different from an aiming task because the person intends to use the object to achieve some type of goal.
How are the different prehension components related?

- The transport (reach) and grasp seem to be temporally coupled and work cooperatively.
- This interdependency is demonstrated by the fact that regardless of the object size and distance, hand closure occurred at approximately 2/3rds of the total movement time of the action (Chiefi & Gentilucci, 1993).
- Further proof is found when the reach and grasp is affected by sudden and unexpected changes in the object’s location or when an obstacle to be avoided interferes with grasping the object.
How is prehension controlled?

Two major factors:

- by Vision
- by the Speed & Accuracy Law
Role Vision Plays

• Prior to the reach the person uses vision to determine the regulatory conditions of the environment in which the action will occur. Common regulatory conditions are:
  – Distance
  – Spatial orientation of the object
  – Location
  – Size of the object
Role vision plays

• During the initial stage of the reach, the limb is directed toward the object.
  – If the reach is ballistic, the reach occurs without sensory feedback and vision plays only provides:
    • Time to contact information (\(\tau\)),
    • Displacement information, and
    • Velocity information.
  – If the reach is performed under closed loop control, vision feedback information is used constantly during prehension by the performer.
Role Vision Plays

• Vision is very important in the grasp and manipulation stage.
  – Enables one to make slight corrections that occur just before the grasp
  – Vision is necessary when to grasp
  – Binocular vision aids the size of grip and force of grip
  – Person needs to look directly at the object for the grasp (point of gaze).
Prehension and Fitt’s Law

Prehension applies to speed accuracy trade-off law, that is, the time of prehension (movement time) is affected by distance of the reach and size of the object.
Fitt’s Law

• Speed-Accuracy Trade Off

• Fitt’s Law provide a mathematical model
  – MT = a + blog₂(2D/W)
  – Variables that predict performance is distance to move and target size

• Fitt’s law has an index that measures the difficulty of the task (ID’s)
The development of prehension

• Phase I Reaching & Grasping
  – One-handed reaching
  – The child reach when they see an object.
  – Once the child makes manual contact with the object, vision facilitates hand closure (grasp)
    • Child decides when to grasp based on what they visually perceive.
Prehension
The development of prehension

• Phase II Reaching and Grasping
  – The child attempts different types of grasps (differentiation)
  – Infant uses two hands to acquire an external object
  – They can use vision to correct their reach
  – The role of vision in grasp to close the hand diminishes and becomes tactile stimulated.
Prehension

Halverson (1931) classic study of prehension found that there was three basic and progressive methods of reaching.

1. Sweeping the hand and arm in a backhand manner toward the object
2. Scooping the hand and arm from different angles.
3. Direct reach
Prehension

Clifton et al. (1993) videotaping infants reach for a rattle or glowing object in light and dark environments.

The reach and grasp is enhanced if they can view their own hands.
Prehension

Development from Phase I to Phase II reach and grasp

- 4 months prehension is controlled by the shoulders and arms; incapable of making contact with the object.
- 5 months prehension is controlled by wrist, hand, and finger control; plus thumb in opposition to the fingers; crude contact with object.
- 6 months a squeeze grasp emerges (fingers close around the object.
- 9 months prehension can be controlled by thumb and one finger (pincerlike control); fingertips of the 3 fingers oppose the action of the thumb in the grasp.
- 13 months fingers oppose the action of the thumb without hand being stabilized.
- 18 months the child can finally release the object.
Prehension

According the Halverson prehension occurs in predictable evolving stages with increasing age (next slide)
<table>
<thead>
<tr>
<th>Type of Grasp</th>
<th>Weeks of Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Contact</td>
<td>16</td>
</tr>
<tr>
<td>Contact Only</td>
<td>20</td>
</tr>
<tr>
<td>Primitive Squeeze</td>
<td>20</td>
</tr>
<tr>
<td>Squeeze Grasp</td>
<td>24</td>
</tr>
<tr>
<td>Hand Grasp</td>
<td>28</td>
</tr>
<tr>
<td>Palm Grasp</td>
<td>28</td>
</tr>
<tr>
<td>Superior-Palm Grasp</td>
<td>32</td>
</tr>
<tr>
<td>Inferior-Forefinger Grasp</td>
<td>36</td>
</tr>
<tr>
<td>Forefinger Grasp</td>
<td>52</td>
</tr>
<tr>
<td>Superior-Forefinger Grasp</td>
<td>52</td>
</tr>
</tbody>
</table>
Prehension

Recent research by Newell et al. (1989) indicated that one to two hand grasping and differentiation of the object size is related to the child’s object-to-hand-size ratio, that is, if the object were scaled to the subject hand size it occurs the grasp is similar to an adult pattern as early as the age of 6-7 years old.
Life time development

Development of the prehension is proximodistal

At 1 year of age, grasping and reaching development is related to walking, that is, two-hand grasping becomes more pronounced on all reaching tasks at the time the child begins to walk.

Continues to develop through out the first decade of life.
- Trajectory and magnitude of fingers opening
- We open our hand wider with experience
Refining & Training Prehension

In the beginning repeat the grasp and reach with the same familiar object (shape, size, and weight) this develops the ability to differentiate between objects and improve the one’s anticipation of weight, force, and velocity of prehension.

Then vary sizes, shapes, and weight of the objects and require different reaching and grasping techniques in light and dark environments.

Realize that one’s control of the rate of speed of their grasp and force of the grasp in the beginning of retraining is negatively associated but with practice becomes similar (Pare & Dugas, 1999).

Provide a variety of functional (real life tasks) that involve reaching, grasping, and object manipulation.