

**Fact Sheet**

**Motor Planning After Brain Injury**

**Author: Shailesh Kantak, PT, Ph.D**

Text

Description automatically generatedA picture containing drawing

Description automatically generated

Accurate and fast actions necessary for optimal functioning in daily life rely on the ability to effectively plan motor actions. Motor planning refers to cognitive-motor processes that evolve prior to movement onset, and integrate sensory information with movement goal for the purpose of generating the upcoming movement1. Motor planning includes multiple processes such as establishing motor goals, selecting the most optimal actions to accomplish the goals and specifying appropriate movement parameters (e.g., force, speed) to execute those actions2. Brain injury resulting from trauma or stroke can profoundly impair motor planning of goal-directed actions and impede functional independence. Importantly, motor planning deficits pose significant challenges to rehabilitation and safety after brain injury.

Common motor planning deficits after brain injury may manifest as poor goal or action selection and impaired movement specification1,3. Poor goal selection is evident in individuals with deficient executive function and attention who may persevere on a goal that is not in alignment with their function. Impaired action selection is inferred from an incorrect action or action sequence when performing a goal-directed task. For example, a patient may try to propel their wheelchair without unlocking the wheels. Such errors in action selection or sequence during tool use not only impair functional performance, but also compromise safety. Finally, if movement specification is impaired, patients may not use appropriate force/speed to complete the movement despite having the capacity to do so4,5. For example, a patient may have sufficient muscle strength/power and sensation in the lower extremity, but may be slow or unable to rise from a chair. Apraxia is a type of motor planning disorder that is associated with impaired spatiotemporal errors in tool-related gesture pantomime to the sight of tools, to command and upon imitation of others6. Often tested using the unaffected upper extremity, apraxia is known to influence activities of daily living and caregiver burden.

Assessment of planning deficits and apraxia is complex. A careful neurological examination is necessary to ensure that the patient’s movement deficits cannot be fully explained by muscle weakness, spasticity, or sensory loss. Apraxia is often assessed by testing the ability to pantomime (e.g., show me how you would use a pair of scissors), produce meaningful (e.g., salute) and meaningless gestures and imitation6. While standardized tests of apraxia are available (e.g., TULIA), the extent to which they relate to or can predict functional independence in activities of daily living is largely unknown. Therefore, until a “gold standard”, clinically-relevant assessment of apraxia is

1. Peters S, Handy TC, Lakhani B, Boyd LA, Garland SJ. Motor and visuospatial attention and motor planning after stroke: Considerations for the rehabilitation of standing balance and gait. *Phys Ther*. 2015;95(10):1423-1432. doi:10.2522/ptj.20140492

2. Wong AL, Haith AM, Krakauer JW. Motor Planning. *Neuroscientist*. 2014;(June). doi:10.1177/1073858414541484

3. Stewart JC, Dewanjee P, Shariff U, Cramer SC. Dorsal premotor activity and connectivity relate to action selection performance after stroke. *Hum Brain Mapp*. 2016;37(5):1816-1830. doi:10.1002/hbm.23138

4. Mani S, Mutha PK, Przybyla A, Haaland KY, Good DC, Sainburg RL. Contralesional motor deficits after unilateral stroke reflect hemisphere-specific control mechanisms. *Brain*. 2013;136(Pt 4):1288-1303. doi:10.1093/brain/aws283

5. Schaefer SY, Mutha PK, Haaland KY, Sainburg RL. Hemispheric Specialization for Movement Control Produces Dissociable Differences in Online Corrections after Stroke. *Cereb Cortex*. 2011;22(6):1407-1419. doi:10.1093/cercor/bhr237

6. Buxbaum L, Haaland K, Hallett M, et al. Treatment of limb apraxia: moving forward to improved action. *Am J Phys Med Rehabil*. 2008;87(2):149-161. doi:10.1097/PHM.0B013E31815E6727

7. Cassidy A. The clinical assessment of apraxia. *Pract Neurol*. 2016;16(4):317-322. doi:10.1136/PRACTNEUROL-2015-001354

8. Smania N, Aglioti SM, Girardi F, et al. Rehabilitation of limb apraxia improves daily life activities in patients with stroke. *Neurology*. 2006;67(11):2050-2052. doi:10.1212/01.WNL.0000247279.63483.1F

9. Donkervoort M, Dekker J, Stehmann-Saris FC, Deelman BG. Efficacy of strategy training in left hemisphere stroke patients with apraxia: A randomised clinical trial. *https://doi.org/101080/09602010143000093*. 2010;11(5):549-566. doi:10.1080/09602010143000093

10. Geusgens C, van Heugten C, Donkervoort M, van den Ende E, Jolles J, van den Heuvel W. Transfer of training effects in stroke patients with apraxia: an exploratory study. *Neuropsychol Rehabil*. 2006;16(2):213-229. doi:10.1080/09602010500172350

11. Howard CD, Li H, Geddes CE, Jin X. Dynamic Nigrostriatal Dopamine Biases Action Selection. *Neuron*. 2017;93(6):1436-1450.e8. doi:10.1016/j.neuron.2017.02.029

12. Levac DE, Glegg SMN, Sveistrup H, et al. Promoting Therapists’ Use of Motor Learning Strategies within Virtual Reality-Based Stroke Rehabilitation. Haddad JM, ed. *PLoS One*. 2016;11(12):e0168311. doi:10.1371/journal.pone.0168311

A Special Interest Group of

**Contact us:**

ANPT

Phone: 952.646.2038

info@neuropt.org

www.neuropt.org

a component of

**Produced by**

Text

Description automatically generatedA picture containing drawing

Description automatically generated

Assessment of planning deficits and apraxia is complex. A careful neurological examination is necessary to ensure that the patient’s movement deficits cannot be fully explained by muscle weakness, spasticity, or sensory loss. Apraxia is often assessed by testing the ability to pantomime (e.g., show me how you would use a pair of scissors), produce meaningful (e.g., salute) and meaningless gestures and imitation6. While standardized tests of apraxia are available (e.g., TULIA), the extent to which they relate to or can predict functional independence in activities of daily living is largely unknown. Therefore, until a “gold standard”, clinically-relevant assessment of apraxia is tested and standardized, it is clinically prudent to consider functional and behavioral movement assessment in ADL tasks, and identify and interpret errors in goal conceptualization, action selection and specification7.

Interventions to improve motor planning and remediation of apraxia can be categorized into two broad categories: Restitution of apraxic deficits and skill-specific training.

* Restitution of apraxic deficits
  + Use of gesture training to commonly used tools have yielded improvements in performance of gesture comprehension, praxic function and care-giver evaluation of patient’s ADL independence8.
* Skill-specific training with a focus on improving goal conceptualization/selection, action selection and movement specification.
  + Errors in goal conceptualization can be remediated by strategy training that emphasize the use of self-verbalization, and external cueing (i.e., use of pictures/environmental cues) in the context of skill practice9,10.
  + Deficits in action selection can be addressed through motor training that emphasizes selection of appropriate actions dependent on external cues (e.g., having patients choose a leg to step on depending on an external cue during balance training). Action selection can also be improved through reinforcement learning that rewards correct responses and behaviors through meaningful, extrinsic rewards11.
  + It is therefore crucial that instructions and feedback provided during training are specific to promote selection of more desirable actions than less desirable ones.
  + Movement specification is promoted through manipulation of practice structure such as variable practice structure that allows mapping of movement parameters to object goals12.
  + Finally, task-specific training is most effective when it is optimally challenging to patient capabilities in skill performance.

a component of

**Produced by**

**a Special Interest Group of**

**Motor Planning After Brain Injury**