

Explicit and implicit motor learning in Cerebral Palsy: Moving toward a tailor made approach

John van der Kamp

Faculty of Behavioural and Movement Sciences, *Vrije* Universiteit Amsterdam

Moving towards a tailor made approach in motor learning

- Trying to optimize motor learning rate and outcome
- Proposition :

Athletes with Cerebral Palsy with good (verbal) working memory profit more from explicit learning, while individuals with poor verbal working memory benefit more from implicit learning. The latter group of athletes are more often found among individuals with right unilateral CP.

Explicit and implicit motor learning

explicit learning

“the ball is placed on fingertips, the wrist is completely flexed, and the elbow is before the ball ..”



“mmm .?.”



implicit learning

“643, 635, 627,
619, 611, 603,
595 ...”



Methods for implicit learning

- Aim: reducing the accumulation conscious knowledge
 - dual-tasking
 - analogy learning
 - errorless learning (i.e., minimizing errors)
 - external focus of attention

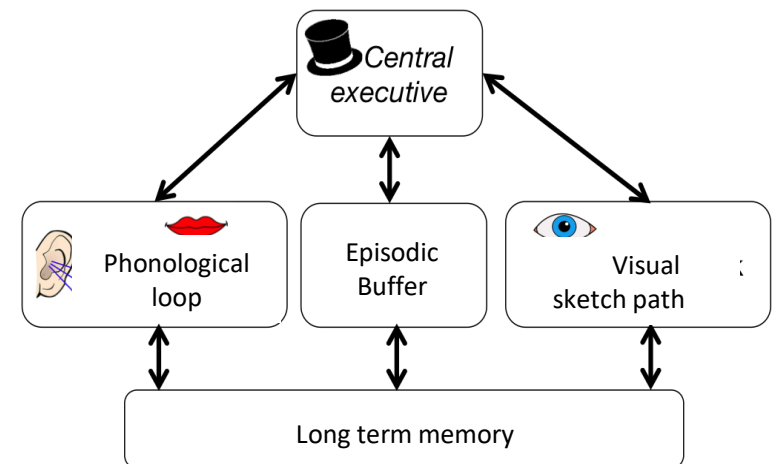
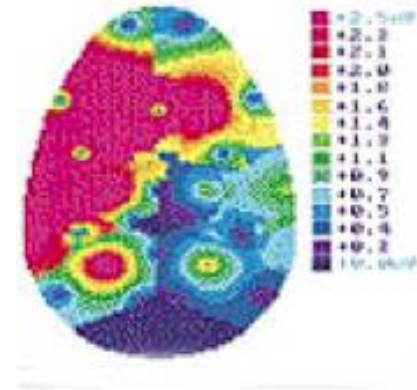


Put your hand
in the cookie
jar!



Some pertinent findings

- Learning outcomes are equal, but performance after implicit learning is less affected by anxiety
- Explicit motor learning is associated with synchronized activity of verbal and motor planning areas in the left-hemisphere
- Explicit learning is promoted by strong verbal working memory, while implicit learning may rely on visual-spatial working memory



Athletes with Cerebral Palsy with good (verbal) working memory profit more from explicit learning, while individuals with poor verbal working memory benefit more from implicit learning. The latter group of athletes are more often found among individuals with right unilateral CP.

Chunks of evidence:

- Individuals with right-unilateral CP (i.e., left-hemisphere damage) encounter problems in conscious control of movement
- Individuals with overloaded working memory show reduced motor learning
- Individuals with right-unilateral CP (i.e., left-hemisphere damage) show reduced explicit motor learning

Conscious control did not reduce skilled performance in *all* soccer players with right unilateral CP



- In typically developing individuals and individuals with left unilateral CP conscious control reduces skilled performance
- Some individuals with right unilateral CP have problems with conscious control

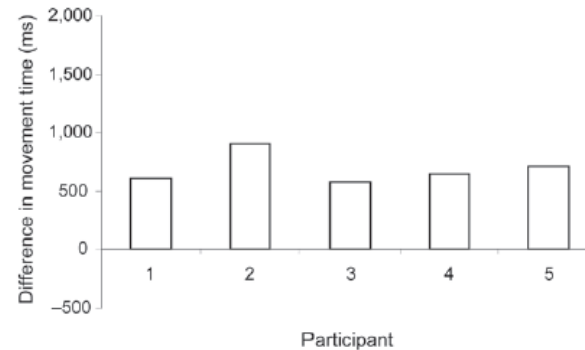


Figure 3 — Movement time differences between the control condition and the task-relevant focus condition, for participants with left hemiparesis. Positive values indicate slowing down in the attention manipulation condition relative to the control condition.

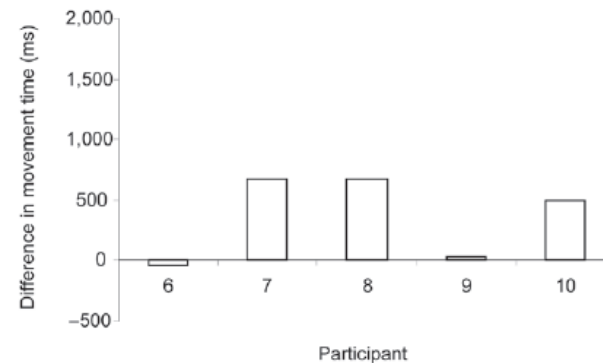


Figure 5 — Movement time differences between the control condition and the task-relevant focus condition, for participants with right hemiparesis. Positive values indicate slowing down in the attention manipulation condition relative to the control condition.

Steenbergen & van der Kamp (2008) *Motor Control*

Athletes with Cerebral Palsy with good (verbal) working memory profit more from explicit learning, while individuals with poor verbal working memory benefit more from implicit learning. The latter group of athletes are more often found among individuals with right unilateral CP.

Chunks of evidence:

- Individuals with right-unilateral CP (i.e., left-hemisphere damage) encounter problems in conscious control of movement
- **Individuals with overloaded working memory show reduced motor learning**
- Individuals with right-unilateral CP (i.e., left-hemisphere damage) show reduced explicit motor learning

Children with CP with working memory overloading showed reduced learning in bocchia throwing

- Children with explicit (i.e., error strewn) and implicit (i.e., error minimized) learning showed same rate of learning
- Children who made few errors, who showed less conscious control, and had no verbal working memory problems, increased performance the most.
- Possibly, overloading working memory (i.e many errors and/or poor working memory led to reduced learning

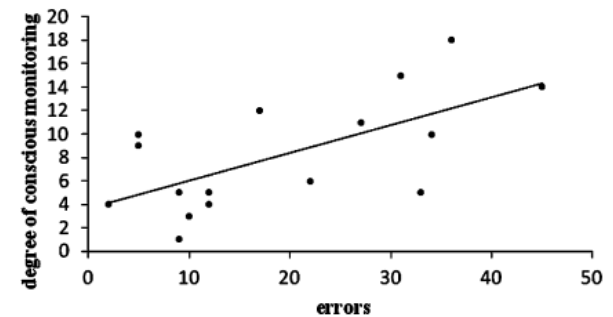


Fig 4. Correlation between the amount of errors made during practice and the degree of conscious monitoring.

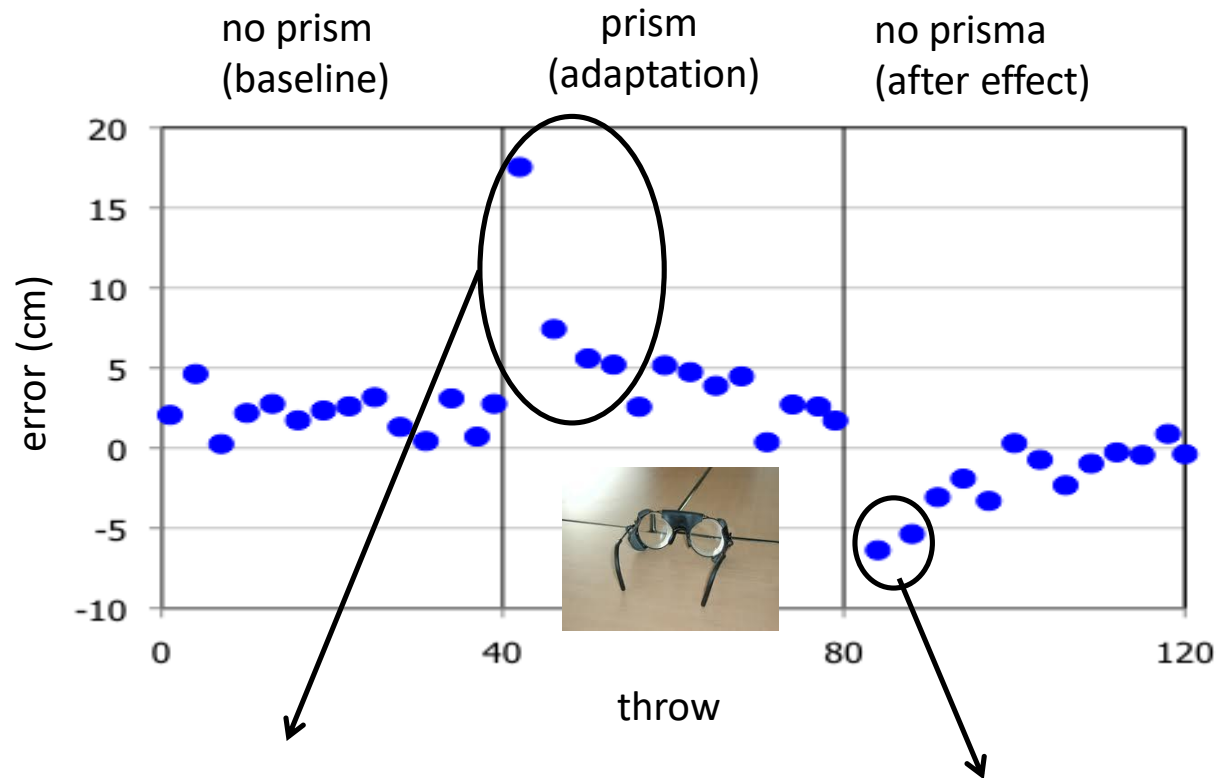
Van Abswoude, Vieira, van der Kamp & Steenbergen (20158)
RiDD

Athletes with Cerebral Palsy with good (verbal) working memory profit more from explicit learning, while individuals with poor verbal working memory benefit more from implicit learning. The latter group of athletes are more often found among individuals with right unilateral CP.

Chunks of evidence:

- Individuals with right-unilateral CP (i.e., left-hemisphere damage) encounter problems in conscious control of movement
- Individuals with overloaded working memory show reduced motor learning
- **Individuals with right-unilateral CP (i.e., left-hemisphere damage) show reduced explicit motor learning**

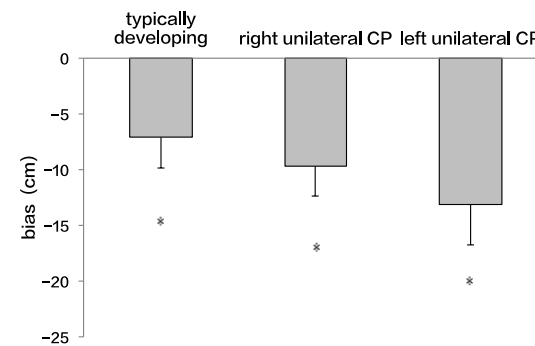
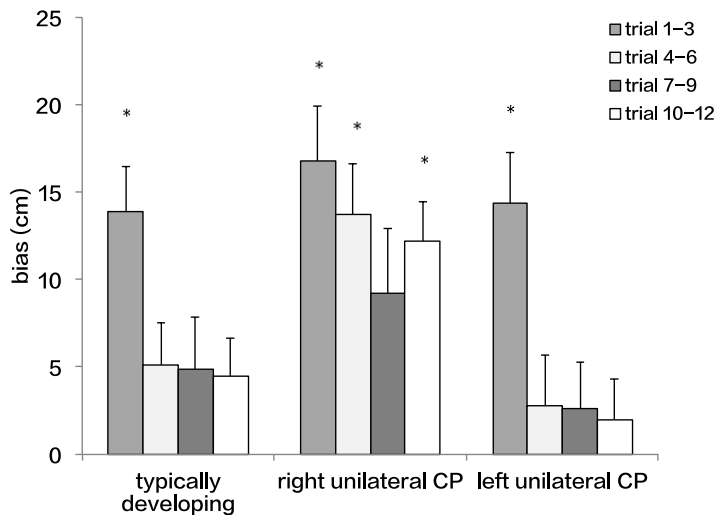
Indicators of explicit and implicit learning in prism adaptation



rate of adaptation → explicit learning

after-effect → implicit learning

Individuals with right unilateral CP show reduced adaptation (i.e., explicit motor learning)



Van der Kamp, Steenbergen & Masters (2018) *Disability & Rehabilitation*

- Individuals with right unilateral CP adapt slower, individuals with left unilateral CP adapt as quickly as typically developing children
- Both right and left unilateral CP show enhanced after-effect (i.e., implicit learning)

Moving towards a tailor made approach in motor learning

Athletes with Cerebral Palsy with good (verbal) working memory profit more from explicit learning, while individuals with poor verbal working memory benefit more from implicit learning. The latter group of athletes are more often found among individuals with right unilateral CP.

Additional considerations:

- Circumstantial evidence: as yet, no direct evidence for the proposition
- Further scrutinize relationships between visuo-spatial working memory left unilateral CP and implicit learning
- Research in stroke suggest that proprioception is also potential mediator (i.e., poor proprioception necessitates explicit learning).