A Scoping Review of the Constraints-Led Approach to Eliciting Motor Skill Acquisition

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Introduction

The Constraints-Led Approach (CLA) has surfaced in recent decades as a promising new avenue by which pedagogues may better foster motor skill acquisition among prospective learners. Fundamentally, the approach posits that the manipulation of constraints (i.e., features of an organism, their environment, and the task at-hand that together interact to define said individual’s opportunities for action) on the part of the practitioner can function to facilitate the emergence of certain movement patterns (Schmidt & Lee, 2020). Intentional manipulation of said constraints is thus considered (by proponents of the approach) an effective means whereby a practitioner may promote a learner’s discovery of appropriate movement solutions (Schmidt & Lee, 2020). Underpinning this approach is a theoretical framework entitled Non-Linear Pedagogy, of which a fundamental tenet is the refutation of prevailing notions that universally optimal movement solutions do, in fact, exist. This framework is in turn founded upon the propositions of the theoretical rationale of motor behavior entitled Ecological Dynamics.

Purpose:

We sought, in our work, to ascertain the extent to which the implied effectiveness of this approach (for eliciting motor learning) is substantiated by empirical work in the literature however, also inherent to our mandate was garnering an understanding of the nature of these existing empirical works, in terms of research design, sporting context, sample demographic, metrics utilized, among other features.

The gardener cannot actually “grow” tomatoes, squash, or beans – she can only foster an environment in which the plants do so.

-Stanley McChrystal (as cited in Woods et al., 2020)

Methods

In pursuit of the aims noted above, we conducted a scoping review of the literature pertaining to the CLA for motor skill acquisition, utilizing as the subject of our analysis a comprehensive database composed of empirical studies featuring the approach. A total of 9 databases (and search engines) were explored to obtain relevant and recent articles – with the specific platforms used including PsychINFO, Academic Search Complete, Physical Education Index, CINAHL, Sport Discus, ERIC, CBCA Education, PubMed, and Google Scholar. The keyword search was engineered to retrieve an encompassing yield of relevant work, and was replicated in each database as follows:

-“(non.linear pedagogy” OR “constraints-led (approach” OR method” OR perspective”)) OR “competitive engine OR “ecological dynamic” OR “representative task design” OR “perceptual/motor landscape” AND (”skill acquisition” OR “motor learning” OR “sport” OR “perceptual motor learning”)

Preliminary findings revealed that the quantity of studies devoted to ascertaining learning effects was dwarfed by that of studies concerned with alterations in performance or decision making during the acquisition phase; as such, the scope of our review was narrowed to include these alternative manifestations of the CLA’s utility.

Results & Discussion

Of the collection of articles amassed through our exploratory undertakings, the tally of studies found to include a passable assessment of learning in their investigation of the CLA was a disheartening 14 studies. What we did find there to be an abundance of, however, was studies wherein a constraint manipulation was imposed, but the effects of such only examined within the acquisition phase; that is, any assessments of outcomes were conducted while the constraints-led intervention was still underway. As such, they do not comply with our criteria for a valid assessment of learning, which require that some post-test, retention test, or transfer test be administered subsequent to completion of the CLA intervention, so as to provide evidence that changes arising from said intervention are stable & enduring. For the purposes of our review though, such studies were still deemed useful, given that any changes observed concurrent with a CLA intervention’s implementation suggest that continual adherence to these training practices could bring about long-lasting changes. Conversely, the potential remains for such changes to attenuate in the absence of training, and thus, these studies are not considered to be equitable in value to learning-centric studies (for this review). These studies were thus segmented from learning-centric studies, then assigned either under a “Performance Alteration” or “Decision Making” grouping, according to whether the dependent variables of concern were related to technical performance or tactical behavior, respectively.

Notable Findings Among the Learning-Centric Studies

- 4 of the 14 featured manipulations of both environmental- & task- constraints; 8 of 14 involved only task-constraint manipulation; only 2 of 14 entailed some form of personal constraint manipulation.
- 3 of the 14 involved skilled participants; remaining 11 (of 14) featured novice participants.
- Differences in performance or outcome contexts were found across the 14 studies; 7 of these represent individual sports or performance contexts, and the other 7, team sports contexts.
- Soccer (European football) was the sport that received the most attention in the respective literature, as it was seen featured in 6 of the 14 studies.

Conclusions & Directive

Although the evidence unearthed thus far appears to partially support the purported promise of the CLA, the scarce nature of relevant empirical works wherein a passable assessment of learning is incorporated, coupled with the significant heterogeneity characterising the existing collection of studies, do not endear one to great confidence (as yet) in this as the most effective means for inducing motor learning.

Forwithstanding investigations into the utility of the CLA should aspire to pair constraints-led interventions with robust assessments of learning; further, researchers should seek to sate such investigations in contexts thus far neglected in the literature.

Notably, some are calling for greater efforts to be made by researchers to demystify for practitioners the challenges and, at times confronting, language inherent to the CLA – the intent of such being to foster greater uptake of the approach among pedagogues (Renshaw & Chow, 2019). It is reasonable to suspect that increased interest in the CLA amongst practitioners would translate to greater attention being devoted to the approach (and to identifying its true merit) among researchers – accordingly, we echo such a directive.

CLA Exemplar

Exemplar example of an operationalization of the constraints-led approach, wherein a task constraint (i.e., visual occlusion goggles) is introduced to the performer so as to direct their attention, by means of constraining their visual field, towards salient sources of information in the performance setting (i.e., the motion of the intended pass recipient as opposed to that of the ball) (Dunton et al., 2020). This guides them in their exploration of the field of opportunities for action (governed by interacting constraints), and enables them to perceive, with greater acuity of personal effective and available opportunities; by virtue, this promotes efficacy in realizing situationally optimal movement solutions.

Participants were randomly assigned to one of three groups: Occlusion (OCC), Practice (PRA) and Control (CON). Participants in the PRA groups completed the same intervention as the OCC groups, only without the spatial occlusion goggles and those in the CON group completed testing protocols only.

Figure 3. Trend of yearly publications of articles investigating the efficacy of the CLA with respect to learning.

Figure 4. Experimental and control protocols: participants receive a pass down from, and must return to pass up, a teammate facing from a central position in Goal 1 or Goal 2 – as determined by coach at random (Dunton et al., 2020).

Figure 5. Visual occlusion goggles (Dunton et al., 2020).

Figure 6. (a) Mean scores for response accuracy across groups. (b) Mean scores for response time for each group. (c) Mean scores for control error for each group, error bars indicate standard deviation & * used to identify significant changes. Significant improvements evident in OCC group from pre to post-test (with such improvements maintained in intention-to-treat for each performance variable (Dunton et al., 2020).

Figure 7. Histogram of variance of improvement in accuracy (a) and response time (b), for each group, with * used to indicate significant changes. Significant improvements evident in OCC group from pre to post-test (Dunton et al., 2020).