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Review

Modified perceptual training in sport: A new classification framework

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ABSTRACT

Objectives: To overview a framework that provides a theoretically-grounded approach to predicting the types of modified perceptual training tasks that will stimulate transfer of improved perceptual skills to sport performance environments. Modified perceptual training (MPT) collectively describes on- or off-field sports training tasks that are specifically designed to develop visual and perceptual-cognitive skill. Traditional training approaches in sport include sports vision training and perceptual-cognitive training, while recently, new technologies have enabled a broad range of additional MPT tools to become available to coaches and athletes.
Design: Short literature review and opinion article.
Methods: Literature in the fields of sports vision training and perceptual-cognitive training are summarised and contrasted. A selection of emerging MPT technologies are then overviewed. This leads to the identification of three interacting factors of MPT task design that may influence the task's capacity to transfer improved training performance to actual competition: (i) the targeted perceptual function, (ii) stimulus correspondence, and (iii) response correspondence, which are assimilated with key tenets of representative learning design.
Results: These three theoretically-grounded differences are adopted to support and justify the structure of the Modified Perceptual Training Framework which sets out predictions for future research to test in order to clarify the transfer effect of MPT tools.
Conclusions: The application of the Modified Perceptual Training Framework may assist in future testing, design and selection of beneficial training tools in sport and as such, is predicted to have significant impact in empirical and practical settings.

1. Introduction

To support performance, elite athletes require a combination of general visual skills (e.g. visual acuity, contrast sensitivity, depth perception)[1,2] and performance-relevant perceptual-cognitive skills (e.g. anticipation, decision-making).[3] While these skills are typically developed as a consequence of regular, on-field practice, training techniques are available that can enhance those skills outside of, or in conjunction with, regular training. Perceptual training has commonly included sports vision training (SVT) that uses generic stimuli (e.g. shapes, patterns) optometry-based tasks with the aim of developing visual skills,[4,5] or perceptual-cognitive training (PCT), that traditionally uses sport-specific film or images to develop perceptual-cognitive skills.[6,7] While these traditional formats involve their own specific training tasks, when compared against each other, they present two considerably different training approaches; these task design differences (i.e. targeted perceptual function, training stimuli, training response mode) will be detailed in later sections. Improvements in technology[5–7] have also led to the development of additional tools (e.g. reaction time trainers, computer-based vision training, and virtual reality systems) which claim to enhance perceptual skill using a variety of different equipment in on- and off-field settings that don't necessarily fit in to these existing categories. This observation is due to these emerging approaches using task design factor combinations that differ from both the specific SVT and PCT approaches. That is, while these emerging tools aim to develop specific perceptual skills that may also be trained using SVT or PCT (i.e.

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visual through to perceptual-cognitive), the specific training stimuli and/or training response mode used in training, as well as the training environment in some cases, may differ. To cover this variety of techniques, *modified perceptual training* (MPT) collectively describes on- or off-field tasks that are specifically designed to improve an athlete's perceptual skill. To help establish the value of these MPT tools, this paper proposes a new framework that provides testable hypotheses for future research to clarify the degree to which each could improve performance. We do so by classifying these emerging (and existing) approaches according to a number of key differentiating factors specifically related to the design of MPT tools.

The presumed usefulness of any MPT tool relies on three key assumptions.[4,8] First, the targeted skill should discriminate between athletes of different skill levels. Second, improvements in the skill of interest should be possible through training, and third, any improvement in that skill should transfer to enhanced on-field performance. While meeting the third assumption is undoubtedly the most critical in an applied sense, empirical evidence for the first two assumptions should be considered for all MPT tools. For the first two assumptions, inconsistent empirical support, particularly regarding visual skill in athletes, theoretically undermines the applicability of the third assumption.[9] However, many MPT tools claim to address the third assumption of improved on-field performance, yet investigations of transfer are rare (for an exemplar transfer investigation see Gabbett, Rubinoff[10]). Ideally, transfer tests should provide dynamic, goal-directed tasks that sample the complex perceptual information available within competitive sport contexts that supports functional, sport-specific perceptual and/or physical skill-based performance; that is, transfer tests should be representative of a competition scenario.[11,12] To achieve this representation, suitable transfer tests should be 'field-based' in nature, permitting interaction with 'live' competition elements, such as teammates or opponents, achievable in laboratory, simulation and actual performance contexts (e.g. within training and competition settings or scenarios, or performance statistics taken from such contexts).[13] The strongest empirical evidence for the utility of MPT tools in sport (i.e. evidence for assumption three) may come from existing or future studies incorporating such tests, at minimum, following an MPT intervention, but also ideally as a pre-test in order to assess the inter- and intra-group differences (i.e. training versus placebo and/or control) in transfer test performance stimulated by the MPT intervention. A framework for MPT in sport would provide testable predictions for assessment in future research regarding the design and type of MPT tasks that improve on-field performance more effectively as established through robust study designs incorporating representative transfer tests.

The aim of this paper is to outline a framework that provides a theoretically-grounded approach to predicting the degree to which a MPT approach will improve on-field performance. The paper will firstly review and summarise SVT and PCT approaches before introducing emerging MPT tools and approaches. From this, three overarching differences in MPT design will be identified (i.e. targeted perceptual function, stimulus correspondence and response correspondence). Second, these differences in MPT approaches will be assimilated with principles (i.e. the role of perceptual processes in linking performance-relevant information and action) from representative learning design (RLD),[11] a theory commonly applied in the design of effective field-based skill practice tasks. Finally, principles from RLD will then be adopted to assist in setting-up and discussing the theoretical premise for the new three design factor continua-based framework, before considering the framework's impact in empirical and applied settings.

2. Modified perceptual training: a traditional dichotomy and emerging approaches

2.1. Sports vision training

Traditionally, MPT has been classified as either SVT or PCT, generating a dichotomy of training approaches. Here, SVT incorporates any task drawn from optometric training programmes, commonly used for the remediation of visual problems, but in this context applied to athletes.[4] Sports vision training targets the visual functioning of the eye (e.g. the lens, extraocular muscles) through to the visual cortex and association area of the occipital lobe.[2] In sport, this pathway facilitates vision to optimise the quality of the athlete's visual experience and their moment-to-moment perceptual representations of their environment. SVT operates on the premise that improving the athlete's vision will lead to improvements in competitive performance.[2] While common characteristics such as static and dynamic acuity, and contrast sensitivity are said to be fundamental to elite sport performance,[1] additional skills also linked to sport performance include depth perception, ocular tracking and peripheral sensitivity.[2] These skills may interact to assist the athlete in the detection and identification of visual stimuli (e.g. localizing a tennis ball during its trajectory), discrimination (e.g. separating the tennis ball from a yellow cap worn by a crowd member) and tracking (e.g. following a moving projectile).

A defining feature of SVT is the consistent use of generic stimuli (e.g. alphanumeric symbols, shapes, patterns or colours),[2,14] although the tasks chosen may be tailored depending on the visual demands of the sport or scenario. For example, in interceptive sports such as baseball and cricket where the batter must hit an approaching ball, vergence exercises may be prioritised because developing this skill may assist in sustaining accurate alignment of the eyes on the approaching ball. Further, performing (or responding in) SVT typically involves simple ocular responses, for example, changes to the shape of the lens or ocular muscle contraction/relaxation. In some instances, this is coupled with non-specific manual gestures or manipulations (e.g. finger pointing or using the hands to adjust the training equipment), though this is generally rare. Table 1 provides a summary of common SVT approaches.

Intervention studies using SVT have demonstrated improvements in visual skills as a result of training in sports such as field hockey[14] and tennis,[15] which equates only to evidence for their trainability (i.e. the second assumption). These studies used a combination of generic stimuli tasks taken from optometry approaches (e.g. hart charts, marsden ball, brock string) as well as light-boards or computer-based programs (e.g. D2 Dynavision, Vision Performance Enhancement Program), requiring simple ocular responses or non-specific manual gestures as responses. The targeted visual skills in these studies were pre- and post-tested on either the same task used to train them and/or alternative generic stimuli and response tasks, while no transfer test was used to establish any transfer to improved field hockey or tennis performance.[14,15] Meanwhile, in their 4-group study design (two different SVT tools, placebo and control), Abernethy and Wood[4] demonstrated non-group dependent improvements in select visual skills, but failed to find significant improvement for any group in their transfer test consisting of an on-court tennis forehand drive transfer test that required participants to hit a projected tennis ball accurately towards a specified target zone. These results suggests the third assumption of transfer has not been met and highlights the lack of evidence for using SVT tools to improve performance.

The inconsistent or lack of evidence for the transfer of improved visual skills has been attributed to: training which targets skills that might not limit performance (i.e. voiding the first assumption, and the third by default), improvements as a result of task familiarity