

PREFERRED COORDINATION MODES IN THE FIRST STEPS OF THE LEARNING OF A COMPLEX GYMNASTICS SKILL.

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INTRODUCTION

According to cognitive theories of motor learning, the co-ordination modes adopted at the beginning of learning are determined by prior internal representations, such as a priori knowledge (Kerr, Hughes, Blais & Toward, 1992) or available neighbouring motor schemata (Schmidt, 1982). The dynamical approach of motor control and learning offers an alternative way to interpret these first modes of co-ordination, which are conceived as emergent properties of the intrinsic dynamics of the task: according to this approach, some modes of coordinations appears as natural attractors, and are spontaneously adopted by subjects (Zanone & Kelso, 1992). This point of view seems particularly relevant in the case of completely novel tasks, in which subjects have no prior experience.

Recent works suggested that spontaneous attractors could be characterized by some general features, such as very simple frequency ratios (Peper, Beek & van Wieringen, 1996), and synchronisation of reversal points (Swinnen, Walter, Lee & Dounskaia, 1996). The aim of this experiment was to verify if such general features were able to predict the first co-ordination modes adopted in the learning of a complex gymnastics skill.

We have chosen to analyze the learning of the swings under the parallel bars, in inverted bent position (Figure 1). This task can be modelled as the coupling of two main oscillators: the first one refers to the pendular oscillations of the center of gravity around the hands, and the second to the vertical oscillations of the center of gravity over the shoulder line (mainly determined by the flexion/extension movements of the hip joint). A mechanical analysis of the task suggested that the most efficient pattern, for this task, could be characterized by a 1:2 frequency ratio, and a $90^\circ/270^\circ$ phase lag between these two oscillators (Figure 2a).

We hypothesized that beginners should be captured by a more simple co-ordination, characterized by a 1:1 frequency ratio, and a strict synchronisation of the reversal points of the two oscillators (0° phase lag).

METHODS

8 subjects volunteered for this experiment. None of them had previous experience in gymnastics. They were asked to learn to swing under the parallel bars, in bent inverted hang position (Figure 1). The task was performed during 10 training sessions, with 10 trials for each session. A day of rest was proposed between each session. A

video-taped model was provided at the beginning of each training session. The task was also performed by an expert gymnast, with the aim to validate the predictions of the mechanical analysis.

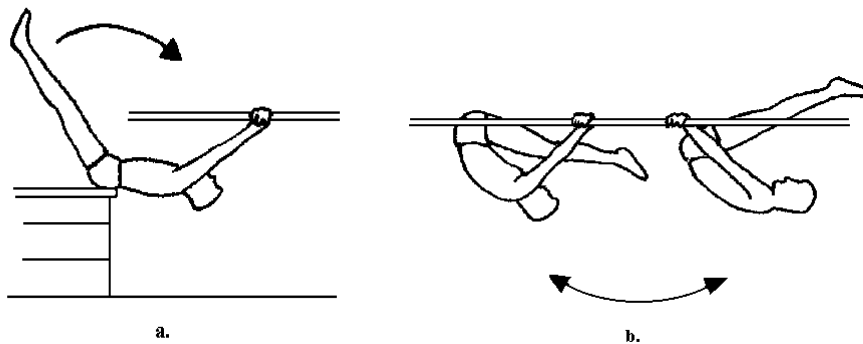


Fig 1: The experimental task (a: starting position; b: swings in bent inverted hang position).

The subjects were equipped with passive markers, located on the right side of the body on (1) knuckle 3 middle finger, (2) wrist axis, (3) glenohumeral axis, (4) ear canal, (5) T12-L1, (6) L4-L5, (7) great trochanter, (8) femoral condyle, (9) lateral malleolus. Markers positions were recorded in two dimensions (sagittal plane) by an ELITE Motion Analyser (BTS), at a sampling rate of 100 Hz. Data were smoothed and filtered, and then the following variables were computed, as time series: (1) the angle between the axis hands-center of gravity of the body (COG) and verticality, and (2) the distance between COG and shoulder line. Then the frequency ratio and the phase lag between the pendular oscillations of the COG around the hands, and the vertical oscillations of the COG over the shoulder line were computed.

RESULTS

Concerning the expert, the results were consistent with our initial predictions. A 1:2 frequency ratio was obtained between the pendular and vertical oscillations of the COG. The vertical oscillations of the COG were initiated near the equilibrium point of the pendular oscillation, both for forward and backward movement (Figure 2a).

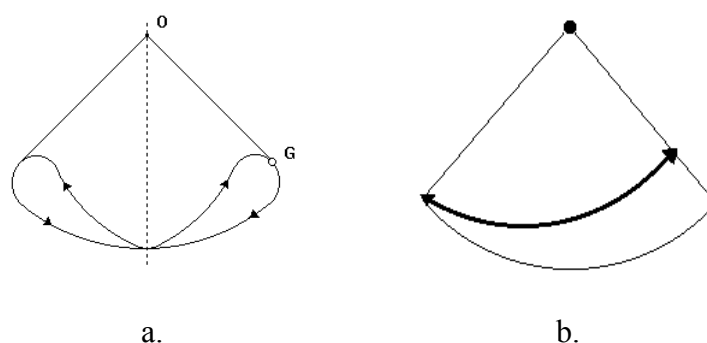


Figure 2: Schematic representation of the trajectory of COG, in the sagittal plane (a. : expert gymnast; b: novice)

The co-ordination mode adopted by beginners was qualitatively different: a 1:1 frequency ratio was obtained between the two oscillators, and the vertical oscillation was initiated at the forward reversal point of the pendular oscillation (Figure 2b).

On average, the phase lag between the two oscillators was constant over the 10 sessions of learning. Nevertheless, an examination of the data of our best learner show a progressive increase of the phase lag: This subject tended to initiate the vertical displacement of the COG more closely to the beginning of the resistant phase of the backward pendular oscillation.

DISCUSSION

The pattern produced by the expert allowed to fully exploit the gravity during the descendant phase of the swing, and to diminish the resistant work of the weight during the ascendant phase, by reducing the torque of the COG around the hands. The co-ordination mode exhibited by beginners appeared clearly less efficient. Nevertheless, it appeared as an easily controllable pattern, characterized by the general features proposed in the introduction.

As this mode of co-ordination was adopted systematically by all our subjects during the 10 learning sessions, it could be considered as a spontaneous attractor, which seemed to irrepressibly capture the behavior of beginners. Then the problem of learning appears to overcome these spontaneous attractors to reach other solutions exploiting more efficiently the passive forces of the system.

The duration of our experiment was not sufficient to observe the transition between this first mode of co-ordination and the expert one. Nevertheless the data obtained with our best learner suggested that this transition was prepared by a progressive evolution of the co-ordination, and more specifically by an increase of the phase lag between the two oscillators. The question remains of the nature (i.e. abrupt vs gradual) of the final transition to a 1:2 frequency ratio co-ordination mode.

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