Very prolonged practice in block of trials: Scaling of fitness, universality and persistence

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HIGHLIGHTS

- Statistical analysis of the reaction times in a psychomotor experiment.
- Very prolonged blocks of trials without rest breaks.
- Performance fitness, persistent behavior and universal patterns.

ARTICLE INFO

ABSTRACT

In this study, we analyze the reaction times obtained from participants in a psychomotor activity composed of a large number of trials without breaks. We numerically evaluate the learning factor directly obtained as the interevent time in the subsequent trials comparing two different blocks of trials. We investigate the learning in terms of average values and their respective variability. In a broader scenario, we show that the learning can be associated with a scale factor acting over the reaction times. Aside from the fitness improvement, we identify that the reaction times have a positively skewed distribution, while their differences are distributed symmetrically as a Laplace distribution whose width diminishes with practice. We found that the differences of the reaction times after practicing become smaller obeying a linear rule. In addition to these universal patterns, we verify that the performance fitness does not exhibit persistence, but their differences do exhibit persistent behavior on the absolute values and anti-persistent behavior for the signs.

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1. Introduction

It is possible to identify the positive effect of practice in everyday situations. Noticeable examples are the process of acquiring new abilities like learning how to read and to write, how to walk, to ride a bicycle, and to play any kind of sport or even a game. As it is well known, the time interval needed to complete a task diminishes with practice at a lower and lower rate while the practice goes on Refs. [1–3]. Traditionally, research in the field of skills acquisition looks to quantify the effect of practice mainly in terms of a reduction in the time interval spent to complete a given task [4–7]. Scientists have done many experiments throughout the years in order to investigate the learning process; the focus has been tasks on blocks with short time of execution divided into short blocks, punctuated with rest breaks. A non-extensive but representative list of examples is pressing buttons, ski-simulator [8,9], tracing geometric figures in a mirror [10], 1023 choice reaction time task [11], alphabet arithmetic task in the study of learning curve [12], memory search task in study of age-related learning

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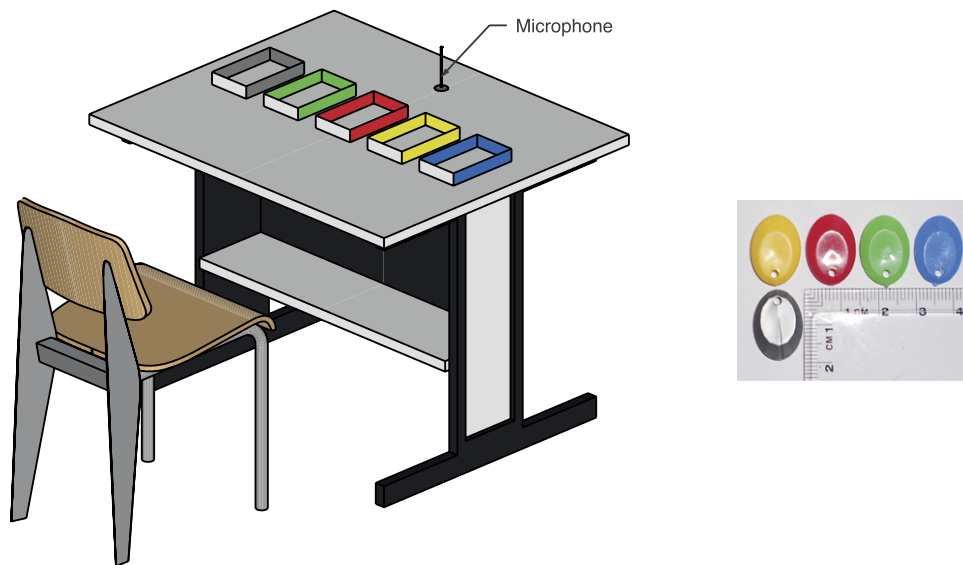
Fig. 1. Setup of the psychomotor activity (left). In the right there is a picture illustrating the dimensions of the beads and their five colors used during the activity. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

differences [13], easy 4 choice reaction time task in the investigation of very prolonged practice [14], movement of a finger or pointer from one place to another in the study of Fitts' Law [15], human stick balancing [16], speed stack bimanually with pyramid of cups in the study of motor learning in children with unilateral cerebral palsy [17], and reading text in the study of text reading fluency in adult readers [18].

Scientists have often performed trials in blocks with the objective of removing some presumed transient randomlike changes from trial to trial while emphasizing the persistent changes or the global trend of learning over the trials [19]. In contrast, a widely accepted perspective on psychomotor ability is that it is not a single general factor, but rather made up of an independent set of subfactors [20]. In this framework, the procedure of blocking data as groups of trials can, eventually, modify or mask intrinsic characteristics such as persistent trends as well as those of the transient changes [19,21].

The aim of this study was to investigate the performance trend on a very prolonged practice composed of blocks of trials, without breaks, in order to evaluate at what level the learning factor is related to the data. Asking the question: is it just a scaling factor or does it act more deeply, disturbing the shape of the probability distribution and altering the presence of correlations? We have used very prolonged blocks (1001 trials) and obtained the interevent times, *aka Reaction Times* (T) from trial to trial, as an alternative approach to the vast literature on shorter blocks of trials [4,5,7,11–13]. We have used commonly employed methods in statistical physics of complex systems to analyze the data. More precisely, we have focused on the distribution and the persistent trend (or memory effect) in the time series of T and their first differences in time series. The persistent behavior in the time series were characterized by Detrended Fluctuation Analysis (DFA), proposed by Peng et al. [22] in their study about DNA sequences time series. The DFA method has been applied in the study of many contexts like synchronization and coordination processes in human movement [23], activity in a social network [24], music [25], chess game [26,27], and stock market data [28–30].

2. The data

The data are from a psychomotor activity performed by participants using a setup as depicted in Fig. 1. A total of 14 healthy adults (8 males and 6 females) with ages varying from 21 up to 38 years (average 25.9 ± 1.4 years) took part in the activity. All the participants are right-handed, have normal or corrected vision, and had no preliminary training. They sit down in front of the setup holding a container with 1001 acrylic flat beads in their lap. The beads are symmetric in shape, as depicted in the setup (see Fig. 1). There was a color sequence for the containers, as shown in Fig. 1; then, the participants had to separate the beads respecting that sequence. Participants should deposit the beads one by one in the container of the corresponding color. The participants had to be fast, but also as accurate as possible. Participants completed one block per day in two different days. Each block consisted of 1001 trials and the only feedback provided for the participants was the time spent on the whole block. It is valid to point out that the exercise employed non-repeated beads to avoid any induced bias due to the proportion of colors. Besides, since when the number of containers is increased, the movement of the participants' hand would be longer to reach some containers than others, only 5 colors were used.

The data collected are the noise of each bead being deposited in the proper container. It was captured by a standard microphone working at a sampling frequency of 44.1 kHz and later converted to numerical data, from where the time