Checking the two-third power law for shapes explored via a sensory substitution device

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In this study, we mentions the first results concerning the validity of the 2/3 power law for shapes explored by Tactos, a sensory substitution device.

Introduction
A fundamental law in the motor skills is the 2/3 power proportion between the movement speed and the shape curvature and which is given by the equation $V(t) = K R(t)^\beta$ or $A(t) = K c(t)^{2/3}$ (Where $V(t)$ tangential speed, $R(t)$ radius of curvature, $A(t)$ angular speed, $c(t)$ curvature, $K$ a constant and $\beta$ a coefficient equal to 1/3 (in the reverse equation the value of coefficient is 2/3 from where the name 2/3 power law).

The first experiments [1, 3] on the co-variation between the speed and the path curvature in the tracing movements underline the tendency of slowing the movement in the most curved parts of the path. Forty years later, Derwort [2] mentions an reverse relation between speed and curvature but the quantitative study of this phenomenon began with the work of Viviani and Terzuolo [6] which propose an analytical formulation of the relation between speed $V$ and radius of curvature $R$ and which were extended to complex paths [4].

In this study, we verify if strategies¹ used by subjects to identify shapes (here ellipses and circles) [7], by mean of a sensory substitution device (Tactos) [5], follow the 2/3 power law and thus preserve the properties of a gesture.

Procedure and results
The data to analyse are files recorded by Tactos software at the time of the experiment. These contain information about the subject’s trajectory on the shape such as: $ms$: the moment when the coordinates are taken, $PX$: the X-coordinate of the trajectory at a given moment and $PY$: the ordinate of the trajectory at a moment given. We used Mathematica software to process the data and here the successive steps: Extraction of columns ($ms$, $PX$, $PY$), display the trajectory, calculation of tangential speed $V$ and the radius of curvature $R$, calculation of logarithms of $V$ and $R$ in order to obtain the $\beta$ value ($Log(V) = Log(K) + \beta Log(R)$) by making a linear regression.

![Continuous follow up](image1)
![Axis + continuous follow up](image2)
![Micro sweeping](image3)

Figure 1. Boxwhistlers for the three strategies (BoxPlot 1 represents $\beta$ and BoxPlot 2 represents the RSquared)

¹ We analyses only trajectories where subjects make either a continuous follow up or a micro-sweeping strategy (see [7]).
Figure 1 shows that the value of $\beta$ is varying between 0.2 and 0.4 and it is closed to 0.3 ($1/3$) for the continuous follow up with a correlation coefficient around 50% (indicated by 2 on each graph). These first results are encouraging and we are still continue the analysis to improve the value of $\beta$. Actually, we are smoothing the data in order to bring closer an irregular subject trajectory to a natural movement (see figure 2). The closer value of $\beta$ to $1/3$ is obtained for a continuous follow up which the closer strategy to a natural movement. It seems possible that the fact of smoothing the data of the other strategies (micro-sweeping and axis with a continuous follow up) improve the $\beta$ values.

![Figure 2. a) Real trajectory of a subject on a horizontal ellipse, b) the same path with a smoothing (500 dots)](image)

**Bibliography**