THE IMPORTANCE OF THE ENERGY PARAMETER IN BEHAVIORAL PHARMACOLOGY

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Introduction

Behavioural pharmacology is an area in preclinical research that investigates the effects of drugs on the behaviour of a laboratory animal. The drugs produce specific effects in the body in terms of energy changes (e.g. biochemical energy, internal energy, entropy). Changes in the potential energy of the body of an animal will result after some time in changes in the kinetic energy of the animal, which will be amongst others expressed by changes in the behaviour. The total kinetic energy is therefore a very important parameter in behavioural pharmacology experiments.

Up to now, most experiments in preclinical research are based on observation of the behaviour of the laboratory animal, either directly by a human observer or later from video recordings. All these methods are using the visual cue as parameter to determine the behaviour of the animal. This applies also for automated methods that are based on video and use the position change of the animal (tracking). These methods lack the possibility to determine the total kinetic energy of the animal. Therefore an alternative method to measure the total kinetic energy in in-vivo experiments is proposed in this paper.

ENERGY & PHARMACOLOGY

To understand the importance of energy, we briefly summarize a few important energy laws:

1. Rule of energy preservation of the body

The sum of the kinetic energy *K* and the potential energy *U* remains constant if no energy is added.

E = K + U = constant (Formula of energetic balance)

2. Potential Energy of the Body

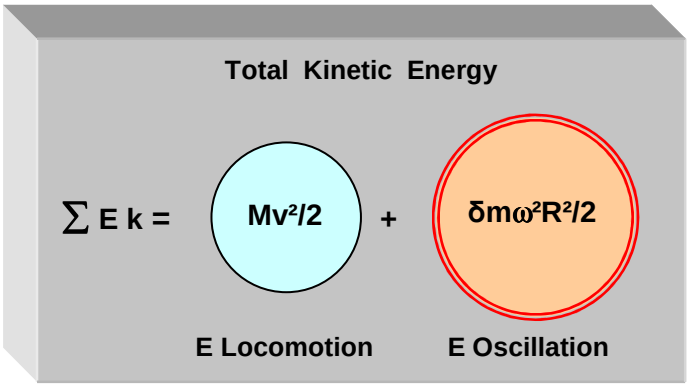
The potential energy of the body is dependent on internal energy of the body, entropy, biochemical energy and thermodynamic energy.

P = ∆**U+ δ(ε − *T*η + *P*v)**

This equation represents total potential energy of the organism, in which ∆**U** is the change in biochemical energy of a system during a process, **ε** is the internal energy, **Tη** is the entropy energy and **Pv** is the thermodynamic energy.

3. Kinetic Energy of the Body

Total kinetic energy of the body is often called energy of the mechanical work done by the body and it is assigned with symbol $\sum$ **E k**. The kinetic energy of the body is equal to the potential energy of the body, expressed in the equation of energetic balance of the body $\sum E_p = \sum E_k$.



E Locomotion = Mv²/2
V = velocity, **M** = total mass of body

E Oscillation = δm ω²R²/2
ω = radial frequency, **R** = radius of oscillation,
δm = mass of oscillating body part

E Locomotion is the kinetic energy resulting from the Locomotion behaviour of the animal, such as walking and climbing.

E Oscillation is the kinetic energy resulting from different movements and behaviors in which the animal doesn't change position, such as scratching, grooming, chewing, sniffing, shaking (wet dog shakes, head shakes, head twitches, tremors, etc.)

In many situations this so-called oscillation energy exceeds the level of locomotory energy
[$\delta m\omega^2R^2/2 >> mv^2/2$ ~ Grooming + Scratching + Chewing + WDS + ….. >> Locomotion + Climbing]

An important pharmacological parameter could be the coefficient Q = Locomotion_Energy/Oscillation_Energy, which indicates how the energy is distributed over these two types of kinetic energy.

METHODS TO MEASURE THE TOTAL KINETIC ENERGY

Force measurement vs. Observation methods

The movements of the behaviors that result in oscillation energy are often short, weak, fast and high frequent and therefore difficult or impossible to observe or record on video (such as head shakes, scratches, chewing). Metris has developed the LABORAS system that is able to measure both types of kinetic energy in a reliable and non-invasive way using force transducers under the cage of the animal.

Matrix method for behavior analysis

Proper analysis and statistics of data is very important in in-vivo experiments. The use of many independent parameters in the automated recognition of a behavior of the animal is therefore crucial.
To recognize a behavior automatically, LABORAS applies the so-called matrix method involving the analysis of several parameters that are derived from the measurement system.

<u>**Your specific behavior**</u> =

$$\begin{vmatrix} X_1, X_2, X_3 \cdots X_n \\ Y_1, Y_2, Y_3 \cdots Y_n \\ A_1, A_2, A_3 \cdots A_n \\ \cdots \\ E_1, E_2, E_3 \cdots E_n \end{vmatrix}$$

The above matrix shows an example of the different parameters for a specific behavior.
Where $X_1, X_2, X_3 \cdots X_n$; $E_1, E_2, E_3 \cdots E_n$ are functions from the specific behavior (e.g. amplitude, frequency ,total energy, locomotion energy, locomotion energy / oscillation energy, etc.).

CONCLUSION

Measuring total kinetic energy in in-vivo experiments is very important to obtain a full ethogram of all behaviors that are shown by the laboratory animal. Traditional methods based on observation or video analyis are too limited for this.
Metris' Laboras system enables measurement of all types of kinetic energy while other non-invasive automated systems for behavior detection can only measure the locomotion component of the kinetic energy (e.g. locomotion energy $mv^2/2$). In addition the matrix method and technology used in Laboras provides a way to measure more behaviors and to recognize them completely automatic and more precisely than ever before.

<u>Laboras</u> is generally considered as the best method for animal behavioral research