A SWOT Analysis on Automating "Measuring Behaviour"

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Introduction

In the past decades technological innovations in many scientific fields, such as molecular biology, biochemistry electrophysiology and histochemistry have facilitated enormously the degree of resolution of independent variables, in addition to accelerating the production of results and read-out parameters. Consequently, this has resulted in new scientific insights. Similarly, a lot of technological innovations have been introduced in studies on (animal) behaviour. The question emerges, however, whether behavioural science has benefited accordingly in terms of generating new parameters, results and insights. We will address this question by applying a SWOT-analysis to discuss the strengths, weaknesses, opportunities and threats of technological innovations that have culminated in the development of automated (high-throughput) home cage systems.

Strengths

Several software packages that enable automating behavioural experiments are commercially available. Among the largest manufacturers are TSE, CleverSys, ANY-maze, Biobserve and Noldus IT. These manufacturers have in common that they are involved in the development of both software and hardware to automate behavioural experiments. Most of them provide their own high throughput home cage system, such as e.g. PhenoMaster (TSE), HomeCage Plus (Biobserve) and PhenoTyper (Noldus IT). Although these systems and/or software each have their own advantages and disadvantages, they have several strong points in common:

- They facilitate the automation of almost all so-called standard behavioural tests, like Open Field, Elevated Plus Maze, Radial Maze, Morris Water Maze, etc.
- The time needed to carry out an experiment is largely reduced.
- They offer more accurate measurements compared to human observations, since a computer is not that easily distracted and/or fatigued.
- They yield a higher reproducibility, because a computer will "observe" the same stream of events in an identical manner.

When it comes to the home cage systems, another strong point of automating behavioural measurements is that the factor time can really be involved, since a computerized system is able to observe 24 hours a day, 7 days a week. Another advantage is that with automated home cage observations the handling and transport of animals from the home cage to the test apparatus becomes redundant, which results in a smaller influence of variation caused by human intervention.

Weaknesses

The focus on automating behavioural experiments is mainly on increasing efficacy and therefore saving time. Hardly any new parameters have been developed. Furthermore, little effort has been made to prolong the time an animal is observed. An automated elevated plus maze test is still run for only 10 minutes rather than measuring for a longer period. Other weaknesses we would like to point out are:

- Instead of observing the animals directly, the experimenter is transformed into a user of a computer application. He or she has to rely on numbers without exactly knowing how they were produced.

- Increased dependence on computer hard- and software. If the computer and/or software malfunction, more and more users will not know how to carry out the experiment.

- The data obtained with a computer can still be "noisy" data that needs to be filtered. Large mistakes, like a disturbance of the experimental setting, will probably be detected, but many smaller mistakes are most likely not. Even a computer can make mistakes by tracking/following something else than the animal.

- Manufacturers of soft- and hardware tend to predetermine how a certain experiment should be carried out, whereas it could be the other way around.

Opportunities

By taking innovation a step further, it will be possible to test animals using a much more ethological approach. For example, by combining transponder technology with video-tracking it will be possible to test a single animal even when it is group-housed, while at the same time determine what other animals in the group are doing at that particular time point. Other opportunities are:

- Enlarging the cage (instead of reducing it) to allow for an integrative measurement of behaviour, that can easily be acquired using dedicated computer software.

- Making use of cleverly designed analytical tools, like the ones created by Golani and colleagues (Golani, Benjamini et al. 1993; Drai, Benjamini et al. 2000; Drai, Kafkafi et al. 2001).

- Collecting vast amounts of data, that facilitates the development of new variables and endpoints.

Threats

The long history of classical methods has yielded an intuitive consensus, be it only superficial, that it is not necessary to describe the used ethograms in detail and that just a simple reference to a previous paper is sufficient. Everybody assumes that behaviours such as freezing, immobility etc. seen in an open field are similar to what one is accustomed to see. This is only based on a kind of historically developed intuition. But when automated methods are introduced, scientists demand validation due to the absence of this intuition as there is no *a priory* conception of computer-used algorithms for a specific behaviour.

The caveat of a more comprehensive approach and a wider spectrum of behavioural elements over a longer period of time is that it yields a complex set of data, especially when technical devices are used which collect data at a high frequency rate. The numbers representing movements, velocity, contour of animals etc. do not have a direct familiar representation in terms of behaviours as one has been familiarized with through the use classical studies. Thus, the data set is at first sight without any meaning. This may be business as usually in other disciplines where math is more generally used and accepted. This is cumbersome however for behavioural scientists who rely on their own way of observing animal behaviour.

Moreover, the analysis requires special tools for exploring the data. When the study is descriptive in nature, special data mining tools are required. When the study is hypothesis driven, the parameters *a priori* defined and those which appeared to have changed without an *a priori* prediction need to be tested. Since the number of parameters may be large, the appropriate analysis and interpretation can be challenging and difficult.

The problem is that behaviour, when observed by humans, elicits associations in terms of meaning or differences. Without human observations, scepticism and doubt emerge about the meaning of abstract numbers. In that case, one is tempted to fall back on familiar and easier behavioural tasks.

So far, technological innovations have given us the opportunity to increase the efficiency by doing more experiments in the same time. However, they have not yielded an increase in the number of variables/endpoints when the data is analysed. If the scientific community can make a distinction between the validation of a paradigm and technological validation, data analysis could benefit from innovation as well. Here, we will present data to illustrate this.

References

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