Measuring Behavior 2016

10th International Conference on Methods and Techniques in Behavioral Research
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Proceedings

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Preface

These proceedings contain the papers presented at Measuring Behavior 2016, the 10th International Conference on Methods and Techniques in Behavioral Research. The conference was organised by Dublin City University in cooperation with the University of Aberdeen and Noldus. The conference was held during May 25-27, 2016 in Dublin, Ireland.

We greeted the attendees at Measuring Behaviour 2016 with the following address: *Táimid an-bhrodúil fáilte a chur romhaibh chuig Baile Átha Cliath agus chuig an deichiú Comhdháil ar Iompar Tomhais. Tá súil againn go mbeidh am iontach agaibh anseo in Éirinn agus go mbeidh bhur gcuairt taitneamhnach agus sásúil. Táimid an-bhrodúil go háirithe fáilte a chur roimh na daoine ón oiread sin tíortha difriúla agus na daoine a tháinig as i bhfad i gcéin. Tá an oiread sin páipéar curtha isteach chuigh an chomhdháil seo go bhfuil caighdeán na bpáipéar an-ard ar fad agus táimid ag súil go mór le hócaid iontach"*. We are delighted to welcome you to Dublin for the 10th Conference on Behavioral Measurement. We hope that the you have a wonderful stay in Ireland and that your visit is both enjoyable and rewarding. We are very proud to welcome visitors from both Ireland and abroad and we are delighted to be able to include in the proceedings such high quality papers.

Building on the format that has emerged from previous meetings, we have a fascinating program about a wide variety of methodological aspects of the behavioral sciences. In addition to purely scientific presentations scheduled into nine oral sessions and ten symposia (covering a topical spread from rodent to human behavior). We have ten speakers in the demonstration showcase events, in which academics and companies demonstrate their latest prototypes. The scientific program also contains a workshop, two tutorials and a lunch-time session on scientific publishing.

We hope this program caters for many of your interests and we look forward to seeing and hearing your contributions and trust it will become a productive, exciting and memorable conference.

May 2016

Cathal Gurrin, Andrew Spink, Gernot Riedel
Chairs
MB2016

The Measuring Behavior Conference Series

Measuring Behavior is a unique conference about methods and techniques in behavioral research. While most conferences focus on a specific domain, Measuring Behavior creates bridges between disciplines by bringing together participants who may otherwise be unlikely to meet each other. At a Measuring Behavior conference, you find yourself among ethologists, behavioral ecologists, neuroscientists, experimental psychologists, human factors researchers, movement scientists, robotics engineers, software designers, electronic engineers, human computer interaction specialists to name but a few. Experience tells us that the focus on methodological and technical themes can lead to a very productive cross-fertilization between research fields. Crossing the boundaries between disciplines and species (from astronauts to zebras) can be extremely inspiring.

Measuring Behavior started in 1996 as a workshop in the framework of a European research project Automatic Recording and Analysis of Behavior, aimed at sharing the results of our project with colleagues from abroad. Organized by Noldus Information Technology and hosted by Utrecht University, Measuring Behavior 96 attracted over 150 participants. From that modest beginning, the conference has grown to a significant international event with several hundred delegates from thirty plus countries. This year is no exception with participants from more than thirty countries registered to attend at the time of going to print.

Over the years, the conference has been hosted by a variety of universities in many locations:

- 1996 (Utrecht) - Berry Spruijt
- 1998 (Groningen) - Jaap Koolhaas
- 2000 (Nijmegen) - Alexander Cools
- 2002 (Amsterdam) - Gerrit van der Veer
- 2005 (Wageningen) - Louise Vet
- 2008 (Maastricht) - Harry Steinbusch
- 2010 (Eindhoven) - Boris de Ruyter
- 2012 (Utrecht) - Remco Veltkamp, Gernot Riedel
- 2014 (Wageningen) - Gernot Riedel, Egon L. van den Broek, and Maurizio Mauri
- 2016 (Dublin) - Cathal Gurrin, Rami Albatal, and Gernot Riedel

In all previous years, the conference had been organised by Noldus Information Technology, who served as the conference organizer and main sponsor, with a number of additional sponsors every year. Measuring Behavior 2016 is the first time that the conference has taken place outside of the Netherlands and is primarily organised by Dublin City University and the Insight Centre for Data Analytics, together with Noldus IT. The organisers have made a big effort to put in place a compelling academic experience as well as an engaging social experience. The welcome reception at the Guinness Storehouse (Irelands number 1 tourist attraction and recently voted the best in Europe) is indicative of the focus on providing a memorable participant experience.

We have also grown in terms of the scientific quality of the conference, with selection of papers now being determined by a process of independent peer-review by an international team of hundreds of reviewers. The scientific program committee is very grateful for all that work that many of you reading this have contributed towards. In the scientific program, which is well balanced between human and animal research, you can find a variety of formats for presentation, interaction and exchange of information. In the past years we have seen that the symposia have become more prominent, and also the demonstration showcase has become more popular. Measuring Behavior is a scientific conference, so special attention is paid to publication of the work presented at the meeting. An important feature of the conference proceedings is that they are all available as open access from http://www.measuringbehavior.org. Now you find yourself at the 10th Measuring Behavior conference, the first conference to take place outside of the Netherlands. The organizers have done their best to prepare an optimal mix of scientific, technical, and social ingredients. We hope that you will find Measuring Behavior 2016 a rewarding and stimulating experience and wish you a pleasant stay in Dublin.

Organization

MB2016 is organized by the School of Computing, Dublin City University, The Insight Centre for Data Analytics, the University of Aberdeen and Noldus.

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Real-time Patterns of Behavior Following Nociceptive Stimulation in Rats

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Abstract

The hot-plate test is employed, in rodents, to assess the analgesic properties of drugs. The surface where the animal is placed is normally maintained at a constant temperature around 50°C or 55°C. For this reason rat's behavior, once placed on the heated surface, can be observed only for few seconds, and a necessary interruption occurs following an a priori-established cut-off to avoid tissue injuries. Such a narrow time window dampened the assessment of fine behavioral characteristics such as the temporal structure of behavior. In the present paper we demonstrate the possibility to apply a refined multivariate approach, known as T-pattern analysis (TPA), to describe the temporal characteristics of the response to hot-plate test in Wistar rats. TPA is a multivariate technique able to detect the existence of statistically significant temporal relationships among the behavioral events in time. 4 groups of subjects administered saline or different doses of morphine have been analyzed by means of quantitative and t-pattern analyses. TPA demonstrated various and important structural changes of behavior: if on the one hand, 24 different temporal patterns have been detected following saline administration, morphine, at the doses of 3, 6 and 12mg/kg, induced a clear-cut and dose dependent reduction, with 5, 2 and 1 patterns detected, respectively.

Keywords: anxiety, pain, morphine, hot-plate, t-pattern analysis, multivariate analysis, rat.

Introduction

The hot-plate test needs little introduction being a model of acute pain widely employed to study the analgesic properties of drugs in rodents. Following the hot-plate test, several behavioral elements, organized in a well-defined behavioral architecture, can be observed and examined [1, 7, 8]. Since the surface where the animal is placed is maintained at a temperature comprised between 50°C and 55°C [8, 14], the test of a subject lasts no more than few seconds [1, 7, 8, 13, 14], being interrupted by the escape of the animal or, more often, by an established cut-off, to avoid tissue injuries. Actually, such a narrow time window dampened the assessment of the temporal characteristics of the behavior in this experimental assay. Aim of the present paper is to provide, for the first time, the description of the temporal characteristics of rat behavior in hot-plate. To this purpose a multivariate approach known as T-pattern analysis will be utilized. In addition, to demonstrate the sensibility and reliability of this multivariate approach in describing even subtle behavioral changes in hot-plate test, the behavioral effects induced by the administration of various doses of morphine will be analyzed as well.

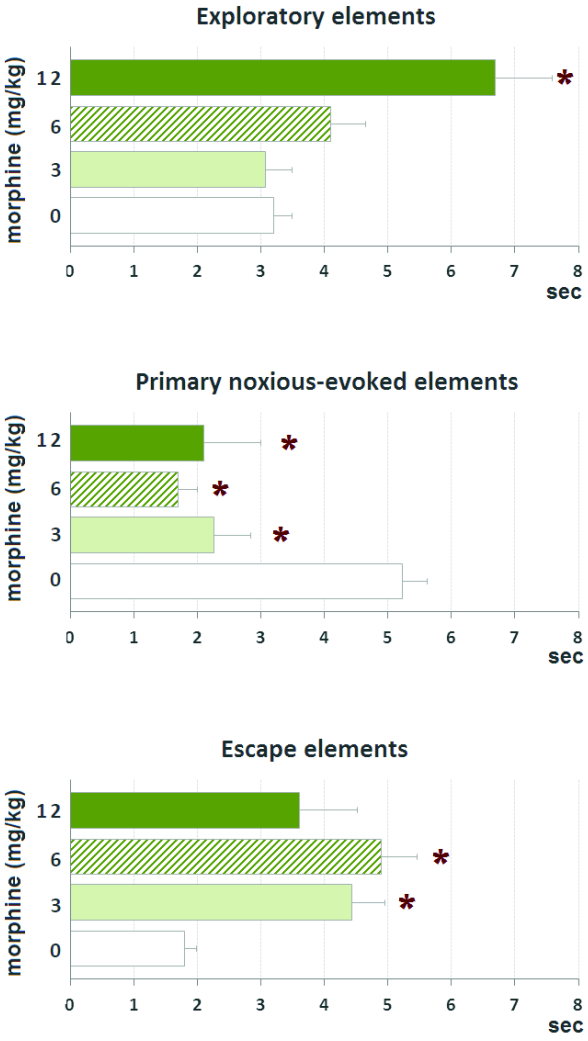

Figure 1. mean durations of Exploratory elements (upper panel), Primary noxious-evoked elements (central panel) and Escape elements (bottom panel). X-axis = time in seconds. Y-axis = morphine dose in mg/kg (0, white bars = saline 1ml i.p.). * = significant difference in comparison with saline.

Method

Animals, drugs and procedures

40 male Wistar rats, 2 months old, weighing 235 ± 15 g, have been employed. Animals were housed in a room maintained at a constant temperature of 23 ± 1 °C, with lights on at 07:00 a.m. and off at 07:00 p.m.. Food and water were freely available. The animals were randomly assigned to four groups, each encompassing 10 subjects: one group received 1 ml saline IP; three groups received 3, 6 or 12 mg/kg morphine dissolved in 1 ml saline IP. The heated surface (54 ± 0.5 °C) was confined by a transparent removable Plexiglas cylinder (20 cm diameter). Rats were transported from housing room to testing room inside their home cages. All subjects, experimentally naïve and tested only once, were placed on the heated surface 30 min after the IP injection and removed after ten seconds.

T-pattern analysis

The behavior of the rodents was recorded by means of a digital camera and stored in a personal computer for following analyses. Video files have been analyzed using a personal computer equipped with a software coder (The Observer, Noldus IT, The Netherlands). On the basis of a suitable ethogram [7, 8], the behaviors of the rats in the hot-plate have been organized on the basis of three main categories: exploratory (walking, sniffing), primary noxious-evoked (hind paw licking, front paw licking and stamping) and escape (climbing, jumping). Mean durations have been utilized to provide a quantitative description of each behavioral category. To explore the existence of possible significant relationships among the events in the course of time, multivariate T-pattern analysis has been carried out. This multivariate approach can be performed by means of a specific software known as Theme (Noldus IT, The Netherlands; Patternvision ltd, Iceland). T-pattern detection algorithm searches for relationships between events in behavioral data by taking into account, the order, timing, and frequency of these events. For instance, given a hypothetical observational period where several behavioral events do occur, the algorithm compares the distributions of each pair of the behavioral elements A and B searching for an interval so that, more often than chance expectation, A is followed by B within that interval. If such a circumstance does occur, A and B are a T-pattern and indicated as (A B). In a second step, such first level t-patterns are considered as potential A or B terms for the construction of higher-order patterns, e.g. ((A B) C), and so on. When no more patterns are detected, the search is concluded. A more detailed description of concepts, theories and procedures behind T-pattern analysis can be found in our recent review [11] and/or in our articles [6, 9].

Statistics

One way ANOVA and Newman Keuls post-hoc test have been carried out to assess possible significant differences among saline and drug-administered groups concerning mean durations. As to multivariate T-pattern analysis, albeit each detected sequence implies a statistical significance, the enormous number of possible relationships raises the question whether detected t-patterns are there only by chance. Theme software deals with such a crucial issue by repeatedly randomizing and analyzing original data. Thus, for each experimental group, the mean number of detected T-patterns (±1 SD) in randomized data is compared with the actual number of T-patterns detected in the real data.

Ethical statement

All efforts were made to minimize the number of subjects and their suffering. Experimental procedures were conducted in strict accordance with the European Communities Council Directive (2010/63/EU) and approved by the official Veterinary Committee appointed by the University of Palermo.

Results

Preliminary results show significant change of mean duration of Exploratory elements. In comparison with control group, NK test revealed significant changes for the higher morphine dose (figure 1). A significant reduction has been detected for Primary Noxious-Evoked elements at all morphine doses. Finally, a significant increase has been detected for Escape elements, with significant differences for morphine 3 and 6 mg/kg groups (figure 1). Concerning T-pattern analysis, preliminary results show 24 different temporal patterns following saline administration (figure 2); morphine administration induced a clear-cut and dose dependent reduction, being the number of different T-patterns 5, 2 and 1, following the administration of morphine 3, 6 and 12mg/kg respectively. Figure 2 also shows that, in saline group, 8 different T-patterns encompass two events, 8 three events, 6 four events, 1 five events and, 1 T-pattern a sequence of seven events. In morphine 3mg/kg, 3 T-patterns encompass two events and 2 three events; as to morphine 6mg/kg, 2 patterns with two events have been detected; finally, in morphine 12mg/kg, 1 only T-pattern of two events has been observed.

Discussion

This study represents the first description of the real time behavioral organization of rats tested in the hot-plate apparatus. In addition, changes elicited by the administration of morphine at various doses have been described. Various methodological aspects underlying the study will be discussed as well

Hot-Plate and transition matrices: pros and cons.

The application of a multivariate technique in the analysis of rat behavior in the hot-plate test is not a new idea. More than two decades ago, indeed, Espejo and Mir co-authored an interesting paper describing the structure of rodent behavior in the hot-plate [12]. The Authors showed that the structure of behaviour in the hot-plate assay can be studied by means of a multivariate approach based on the elaboration of transition matrices. This study has been, probably, one of the first attempts to characterize the behavior of the rodent in the hot-plate by means of a multivariate technique. However, the utilization of transition matrices in the analysis of data sets obtained from behavioral observations has various advantages and disadvantages that should be considered. On this subject, the analysis of rodent behavior in hot-plate is not an exception.

- Advantages: actually, transition matrices do represent a very useful tool to describe the behavior from a different point of view, greatly beyond what the human eye can intuitively perceive [15]. Indeed, by means of transition matrices it becomes possible to characterize the elements of a given behavioral repertoire in terms of reciprocal relationships of different magnitude: probabilities, similarities etc. In addition, transitions matrices and related elaborations can be represented by means of intuitive graphical approaches, such as dendrograms and path diagrams. In our laboratories we have fruitfully utilized transition matrices and related elaborations such as Markovian processes, dendrograms or adjusted residuals to describe rats' behavior in several experimental conditions such as in open field [2, 4], hole-board [3, 5], elevated plus maze [10] and in the hot-plate as well [1, 7, 8].

- Disadvantages: beyond all the obvious differences among researches carried out in different laboratories, all the approaches utilizing techniques based on the elaboration of transition matrices share a common aspect: the representation of behavior resembling a snapshot of the comprehensive observational period. For instance, probabilities of transitions, obtained from a transition matrix, graphically presented by means of a Markov diagram, do illustrate the behavior in terms of reciprocal probabilities of transitions among all the behavioral elements; a dendrogram, obtained utilizing a hierarchical aggregative procedure on the basis of an underlying transition matrix, represents the behavior in terms of similarities among the elements. In other words, a transition matrix does not provide information concerning one of the most important features of behavior: possible relationships among events in time, that is, its temporal structure.

T-patterns in hot-plate

By applying T-pattern analysis, present research sheds light on the real-time temporal features of the behavior of rats. Results show that rat's behavior in the hot-plate, during the nociceptive stimulation, has complex temporal characteristics and even within the boundaries of a narrow observation window (namely, 10 seconds), several complex patterns of behavior are present (figure 2).

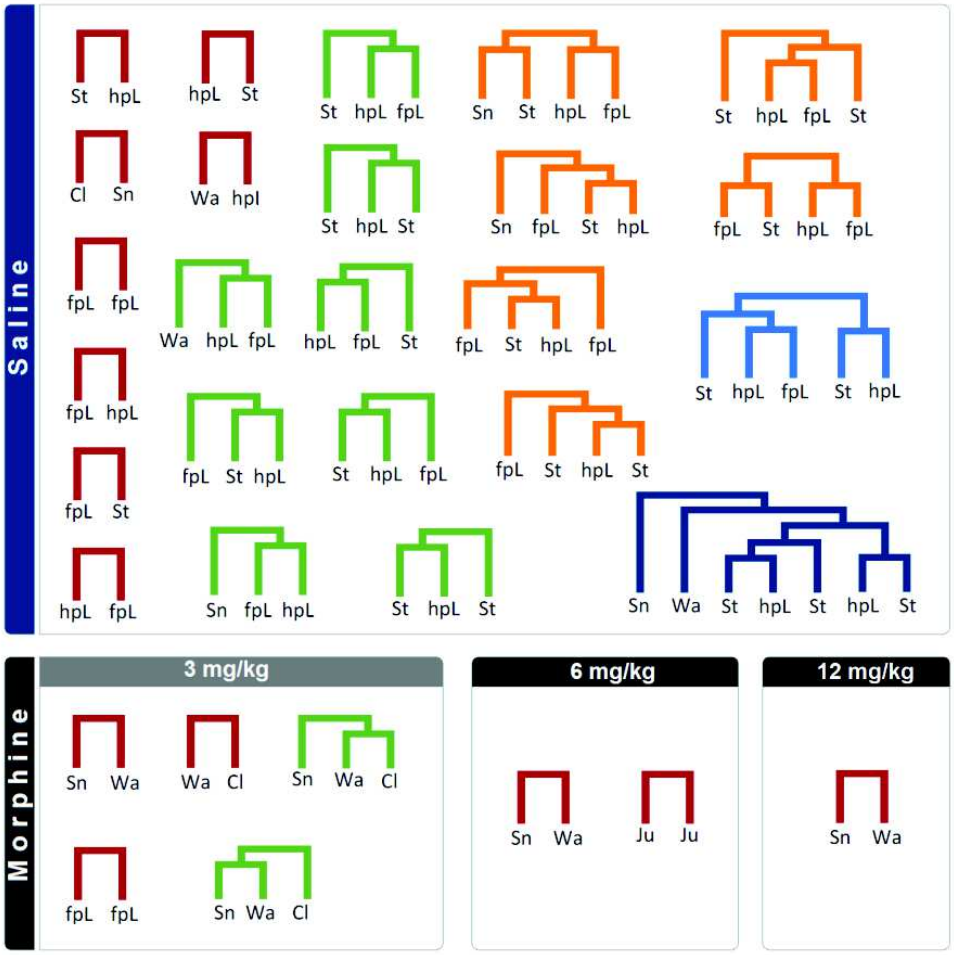

Figure 2. T-patterns detected in saline group (upper panel) and morphine (3, 6, 12 mg/kg) administered groups (bottom panels).

When morphine is administered, substantial changes become evident. First of all, the number of different T-patterns is markedly modified. Actually, at the higher 12mg/kg dose, it has been possible to detect just 1 T-pattern (see figure 2). Notably, following the drug-induced analgesic activity, a completely different behavioral strategy aimed at environmental exploration becomes manifest: if on the one hand the T-pattern encompassing both the exploratory elements (that is, Sniffing and Walking, see figure 2) is absent in saline administered subjects, on the other hand it is present in all morphine injected ones. Thus, it may be supposed that the incoming nociceptive information, by far dominant in animals not injected with morphine, forces the subject to scan all the possible solutions to remove or, at least, to reduce the painful situation. Following the antinociceptive activity of morphine, the contextual priorities radically change because painful information is greatly reduced and, as a consequence an unrestricted exploratory activity (namely, sniffing and walking) becomes possible. Further analyses are currently underway in our laboratories to extend and complete present preliminary data.

References:

1. Casarrubea, M., Sorbera, F., Crescimanno, G. (2006). Effects of 7-OH-DPAT and U 99194 on the behavioral response to hot plate test, in rats. *Physiology & Behavior* **89**, 552-562.
2. Casarrubea M., Sorbera, F., Crescimanno G. (2008). Multivariate analysis of the modifications induced by an environmental acoustic cue on rat exploratory behavior. *Physiology & Behavior* **93**, 687-697.
3. Casarrubea, M., Sorbera, F., Crescimanno, G. (2009). Structure of rat behavior in holeboard: II multivariate analysis of modifications induced by diazepam. *Physiology & Behavior* **96**, 683-692.

4. Casarrubea, M., Sorbera, F., Crescimanno, G. (2009). Multivariate data handling in the study of rat behavior: an integrated approach. *Behaviour Research Methods* **41**, 772-781.
5. Casarrubea, M., Sorbera, F., Santangelo, A., Crescimanno, G. (2010). Microstructure of rat behavioral response to anxiety in hole-board. *Neuroscience. Letters* **481**, 82-87.
6. Casarrubea, M., Sorbera, F., Magnusson, M.S., Crescimanno, G. (2011). T-pattern analysis of diazepam-induced modifications on the temporal organization of rat behavioral response to anxiety in hole-board. *Psychopharmacology* **215**, 177-189.
7. Casarrubea, M., Sorbera, F., Santangelo, A., Crescimanno, G. (2011). Learning influence on the behavioral structure of rat response to pain in hot-plate. *Behavioural Brain Research* **225**, 177-183.
8. Casarrubea, M., Sorbera, F., Santangelo, A., Crescimanno, G. (2012). The effects of diazepam on the behavioral structure of the rat's response to pain in the hot-plate test: anxiolysis vs. pain modulation. *Neuropharmacology* **63**, 310-321.
9. Casarrubea, M., Roy, V., Sorbera, F., Magnusson, M.S., Santangelo, A., Arabo, A., Crescimanno, G. (2013). Temporal structure of the rat's behavior in elevated plus maze test. *Behavioural Brain Research* **237**, 290-299.
10. Casarrubea, M., Faulisi, F., Sorbera, F., Crescimanno, G. (2015). The effects of different basal levels of anxiety on the behavioural shift analyzed in the central platform of the elevated plus maze. *Behavioural Brain Research* **281**, 55-61.
11. Casarrubea, M., Jonsson, G.K., Faulisi, F., Sorbera, F., Di Giovanni, G., Benigno, A., Crescimanno, G., Magnusson, M.S. (2015b). T-pattern analysis for the study of temporal structure of animal and human behavior: a comprehensive review. *Journal of Neuroscience Methods* **239**, 34-46.
12. Espejo, E.F., Mir, D. (1993). Structure of the rat's behaviour in the hot plate test. *Behavioural Brain Research* **56**, 171-176.
13. Lee, Y.F., Lin, C.C., Chen, G.S. (2014). Temporal course of streptozotocin-induced diabetic polyneuropathy in rats. *Neurological Sciences* doi: 0.1007/s10072-014-1848-8
14. Mehta, A.K., Bhati, Y., Tripathi, C.D., Sharma, K.K. (2014). Analgesic effect of piracetam on peripheral neuropathic pain induced by chronic constriction injury of sciatic nerve in rats. *Neurochemical Research* **39**, 1433-1439
15. Spruijt, B.M., Gispen, W.H. (1984). Behavioral sequences as an easily quantifiable parameter in experimental studies. *Physiology & Behavior* **32**, 707-710.