Acta Psychologica 190 (2018) 65–71

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Dissociating decision strategies in free-choice tasks – A mouse tracking analysis☆

Diana Vogel[a,*], Stefan Scherbaum[a], Markus Janczyk[b]

[a] Department of Psychology, Technische Universität Dresden, Germany
[b] Department of Psychology, Eberhard Karls University Tübingen, Germany

ARTICLE INFO

Keywords:
Voluntary actions
Free-choice
Decision strategies
Mouse trajectory
Ideomotor theory

ABSTRACT

Everyday life offers a variety of possible actions, from which we choose one that corresponds to our intended goals. How do these goals and actions interact within the mind? One way to investigate this question is free-choice tasks, where participants freely choose the action they want to perform on any given trial. Such tasks are used in research on voluntary actions and goal-driven behavior, such as ideomotor theory. However, these tasks leave participants with a substantial amount of freedom and allow for different response strategies. Such strategies can, though being hidden in the final data, influence the results, for example by hiding the effects of manipulations of interest. To better understand participants' behavior in free-choice tasks, we used mouse tracking in an ideomotor free-choice experiment, where participants learn the connection between an action and an effect. Subsequently, they have to freely choose between actions, while the former effect is presented as a stimulus. We identified two distinct groups that applied different decision strategies. The first group made the decision at the beginning of or before the trial, irrespective of the yet to be presented effect stimulus. The second group decided within the trial and was affected by the stimulus more often. This suggests that people handle free-choice tasks differently which is expressed in heterogeneous choice patterns and response times and an underestimation of the examined effects. These differences potentially limit the reliability of inferences from free-choice experiments and should be considered in the interpretation of their results.

1. Introduction

Human behavior is characterized by an enormous variety of manifestations. In everyday life, humans have a large range of possibilities of what to do, usually choosing an action that matches their intended goals. Only rarely is behavior entirely determined by a certain stimulus.[1] Yet, psychologists often use paradigms that are mostly reactive, requiring a clearly defined response to a presented stimulus. In contrast to this restricted setting, experiments examining voluntary actions offer the participants a larger range of freedom when dealing with the task. An example, where participants choose the particular response they want to perform on any given trial is *free-choice tasks* (e.g., Berlyne, 1957; Herwig, Prinz, & Waszak, 2007; Janczyk, Dambacher, Bieleke, & Gollwitzer, 2015; Janczyk, Heinemann, & Pfister, 2012; Janczyk, Nolden, & Jolicoeur, 2015; Naefgen, Dambacher, & Janczyk, 2017). This type of task is often used in studies of goal-driven behavior in the context of ideomotor theory (e.g., Elsner & Hommel, 2001; Janczyk, Dambacher, et al., 2015; Janczyk & Kunde, 2014; Janczyk, Nolden, & Jolicoeur, 2015; Pfister, Kiesel, & Hoffmann, 2011). However, the more natural setting comes at the cost of less experimental control. Here, we use mouse tracking in an ideomotor free-choice task to show that the participants' strategies potentially limit the reliability of inferences from free-choice tasks.

1.1. Free-choice tasks in voluntary action research

Research on voluntary actions seeks to understand the mechanisms that cause and control voluntary actions (for an overview, see Goschke, 2003; Haggard, 2008). Voluntary actions are hard to study, since they are by definition independent from an external stimulus or at least only indirectly dependent. This results in them being incompatible with most experimental setups. There are, however, several paradigms that

☆ Authors note: the work of Markus Janczyk is supported by the Institutional Strategy of the University of Tübingen (German Research Foundation, ZUK 63). The work of Stefan Scherbaum is partly supported the collaborative research center 940 (German Research Foundation, grant SFB 940/2 2016).

* Corresponding author at: Department of Psychology, Technische Universität Dresden, 01062 Dresden, Germany.
E-mail address: diana.vogel@tu-dresden.de (D. Vogel).

[1] Perhaps this is only true for unconditioned reflexes that may constitute a special kind of human behavior (see Janczyk, Pfister, Wallmeier, & Kunde, 2014).

https://doi.org/10.1016/j.actpsy.2018.06.012
Received 20 February 2018; Received in revised form 27 June 2018; Accepted 28 June 2018

address voluntary action. One is the free-choice task, where participants are given a set of responses from which they are free to choose which action they want to perform. Importantly, there is no stimulus demanding a preordained action (Berlyne, 1957; Haggard & Eimer, 1999; Janczyk, Dambacher, et al., 2015). There is only a neutral stimulus indicating the onset of a trial. This stimulus can be accompanied by other stimuli, but these also have no imperative character. Therefore, the participants choose the response for themselves in each trial (see also Naefgen & Janczyk, 2018).

There are also other paradigms which address voluntary actions. One example is the voluntary task switching paradigm (e.g., Arrington & Logan, 2004) where participants are given two or more tasks and they can choose in each trail which task they want to respond to. Additionally, there is the paradigm of preferential choice (e.g., Wulff, Mergenthaler-Canseco, & Hertwig, 2018) where participants decide between two more or less risky choices. This manuscript will focus solely on free-choice tasks. This paradigm has also been taken up in the field of ideomotor theory, which seeks to answer the question how actions and goals are related to each other. More precisely, this theory assumes that actions are represented in terms of their corresponding and contingent sensory consequences. Thus, (1) when performing an action, a person experiences the subsequent effects as consequences of their action and automatically acquires associations between the action and the effects. At a later time, (2) the person can then rely on these associations: If they have a goal to achieve a certain effect, this effect's representation is anticipated and mentally activated, and the learned associations in turn (pre-)activate the corresponding action (Janczyk & Lerche, 2018; Elsner & Hommel, 2001; Kunde, 2001; Shin, Proctor, & Capaldi, 2010).

An influential series of experiments by Elsner and Hommel (2001) used free-choice tasks and showed that presenting an effect at the beginning of the trial in a free-choice task "induces" the corresponding action which usually generated this effect previously. Experiments 2–4 of this series consisted of an acquisition phase and a test phase, each employing a free-choice task in both phases. In the acquisition phase, participants pressed either a left or a right response key and each key press produced a corresponding effect (i.e., a low- or a high-pitch tone). In the subsequent test phase, the former effect tones were presented and participants were asked to respond freely to these tones by pressing one of the two possible keys. They could either respond to the tone by choosing the key which corresponded to this tone in the acquisition phase (which will be referred to as the congruent option in the following) or the key which did not correspond to this tone (which will be referred to as the incongruent option). The authors observed that the congruent option was chosen more often than the incongruent option in the test phase, a result replicated in several later experiments (e.g., Hoffmann, Lenhard, Sebald, & Pfister, 2009; Pfister et al., 2011). However, if the presented effects are not relevant for the task (which is true for most of the free-choice tasks) then the response bias is rather small. Short response times (RTs) indicate a certain rate of premature decisions during the performance of free-choice tasks (Elsner & Hommel, 2001; Röttger & Haider, 2017), which is why Elsner and Hommel (2001) introduced a go/no-go task in Experiment 3 to counteract premature decisions. With this task included, participants cannot completely shield from auditory information. From the three different auditory stimuli they hear, there are two requiring a response and one requiring none. Therefore, they cannot choose their response before they hear the stimulus. Introducing the go/no-go task into the free-choice paradigm led to higher RTs and a greater difference in choice ratio between congruent and incongruent choices, indicating a lower rate of premature decisions. However, when Röttger and Haider (2017) used the same method to prevent premature decisions, RTs were still lower than in the forced-choice task and showed a smaller effect. One could argue that RTs in forced-choice tasks are more sensitive to reveal action-effect bindings than choice rates in free-choice tasks. Even acknowledging these ad-hoc explanations, the small response biases and short RTs observed in this task still require an explanation.

1.2. Tracking the decision process in free-choice tasks

The purpose of the present study is to elucidate the decision process in free-choice tasks. We argue that experiments using discrete responses, like computer keyboards or response keys, do not provide a convincing explanation. They do not allow one to examine the response selection process itself. One could try to reveal differences in decision strategies by analyzing RTs. However, using RTs for a categorization is not trivial, since RT is sensitive to many individual factors such as sleep deprivation (Taheri & Arabameri, 2012), arousal (Bagherli & Mokhtari, 2011), age (Porciatti, Fiorentini, Morrone, & Burr, 1999), or IQ (Taimela, 1991). Therefore, a person might be fast or slow simply because of other reasons than the person's decision behavior. Furthermore, short RTs can also originate from a loss of accuracy in favor of magnified speed (Wood & Jennings, 1976). When assigning participants to decision groups according to their RTs, all these factors play a role. This increases the risk of a miscategorization of which decision strategy the participants pursue. Distribution-based approaches might improve accuracy of categorization. If the distribution shows a bi- or multimodal shape, this can be used as an indication for two or more decision strategies and participants could be assigned to decision groups according to their position in the distribution. However, this method must build on assumptions of how the specific decision process shapes the RT distribution.

A more accurate method to determine a person's decision strategy is mouse tracking, which tracks the trajectory of a decision from trial onset to the last point of the response execution. If on a substantial amount of trials participants have chosen the response before stimulus presentation, this would become visible in the trajectories of the mouse movement. Such observations in mouse tracking, in turn, can be used to explain the small response bias in key pressing experiments.

In our experiment, we use a paradigm from Elsner and Hommel (2001, Experiment 3), but with mouse tracking as a continuous response measure. This allows us to track the decision process from trial onset to the finalization of the selected response (Scherbaum, Dshemuchadse, Fischer, & Goschke, 2010). By tracking the decision process for the full trial, we will gain insight into (1) how responses are carried out and (2) whether premature decisions occur.

We first expect that participants choose the congruent option more often, as in the original experiment. Elsner and Hommel (2001) used a go/no-go task to counteract premature decisions, but nevertheless, some participants appeared to choose their response before stimulus onset. Therefore, we secondly expect the participants to use different decision strategies, because the free-choice task allows participants to choose their own strategy in selecting a response. In particular, we expect some participants to perform predominantly premature decisions, while other participants decide during the trial. By analyzing mouse trajectories, especially in the first stage of the trial, we will distinguish premature decision makers from later decision makers.

2. Methods

2.1. Participants

Thirty undergraduate students from the University of Tübingen (mean age = 22 years, 22 female) took part in the experiment. The data of three participants were lost due to errors in recording mouse trajectories. All participants had normal or corrected-to-normal vision and were naive regarding the hypotheses underlying the experiment.

2.2. Apparatus and stimuli

Auditory stimuli were sinusoidal tones of 200, 500, or 800 Hz lasting for 200 ms delivered via headphones.