Cognition 136 (2015) 38–42

Contents lists available at ScienceDirect

Cognition

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

Brief article

Was it me when it happened too early? Experience of delayed effects shapes sense of agency

Carola Haering, Andrea Kiesel *

Department of Psychology, University of Wuerzburg, Germany

ARTICLE INFO

Article history:
Received 23 May 2014
Revised 13 November 2014
Accepted 16 November 2014

Keywords:
Sense of agency
Causality
Action effect delay
Temporal deviation

ABSTRACT

Sense of agency, the feeling of causing a certain event, depends largely on the delay between an action and its ensuing effect: The feeling to control an effect that is caused by our preceding action is stronger the closer the effect follows the action in time. Yet, repeatedly experiencing an effect after a constant delay might alter this general rule. Here, we assessed sense of agency for effects that occurred 0–250 ms after an action in conditions in which the effect either mostly occurred immediately or mostly delayed after 250 ms after the action. Participants who experienced mostly delayed effects rated their influence over the effect's occurrence to be larger the longer the action-effect interval was. Thus, sense of agency is not always stronger at shorter action-effect intervals, but rather depends on the match between the agent's expectations and the actual timing of events.

1. Introduction

How do we know which of our actions causes which effects in the environment? When we interact with our environment, we often do not deliberately think about action-effect relations, but simply act – for instance pressing a light switch – and have the immediate feeling that the effect – light – was caused by our action.

One key factor for perceived causality is temporal contiguity. The longer the delay between two events, the less likely it is that the second event will be judged to be caused by the first event (Choi & Scholl, 2006; Greville & Buehner, 2010; Michotte, 1963; Shanks & Dickinson, 1987).

Sense of agency, that is, the immediate feeling of causing an effect, is a special case of perceived causality. While we can perceive causality between any two entities in the environment, for instance between two billiard balls (Michotte, 1963), agency only refers to effects caused by actions. Nevertheless, the same factors that determine perceived causality are assumed to affect agency judgments (Eagleman & Holcombe, 2002; Haggard, 2005; Moore, Lagnado, Deal, & Haggard, 2009). Accordingly, temporal contiguity between an action and its effect is assumed to determine sense of agency.

Although perceived causality generally decreases the larger the delay between action and effect, we occasionally face situations with considerable delays between our actions and their effects. For instance, when we press a switch, it can take seconds until the energy saving light bulb brightens up (Buehner & May, 2002). Nevertheless, we have no doubt that our action caused the light to turn on. Yet, the question remains whether in such situations, we directly sense agency to have caused the effect. Furthermore, it is an open question whether we sense less agency for effects that occur earlier than usual. For instance, if we start a computer program from the server which usually it takes 1 s to start, do we sense less agency if the program starts earlier than usual?

There is some evidence that the effect of temporal contiguity on causal perception is modulated by expectations (Einhorn & Hogarth, 1986; see also Buehner & May, 2002,

* Corresponding author at: Department of Psychology, University of Wuerzburg, Roentgenring 11, 97070 Wuerzburg, Germany. Tel.: +49 (0)931 3182766; fax: +49 (0)931 3182815.
E-mail address: kiesel@uni-wuerzburg.de (A. Kiesel).

http://dx.doi.org/10.1016/j.cognition.2014.11.012
0010-0277/

2003, 2004). When the experimental design and/or instructions suggest that a delay between action and effect is probable, the detrimental effect of delays on causality judgments was alleviated (Buehner & May, 2002, 2003) or even abolished (Buehner & May, 2004). A study by Buehner and McGregor (2006) revealed that knowledge can even reverse the detrimental effect of temporal delays on causality judgments. Participants first watched a marble traveling through a Bernoulli board and causing a light onset when reaching the bottom. Participants were instructed and perceived that the marble traveled slower when the tilt of the board was low rather than high. Then the board was covered and participants judged if the marble caused the light that occurred after a short or a long delay. When the tilt of the board was low, causality judgments were larger after the long than the short delay, i.e. the opposite result that would be expected if temporal contiguity determined causality judgments.

Interestingly, there is no need to explicitly inform participants about the delay of an effect, but they can acquire knowledge about expected delays based on repeated experience. Participants learn when an effect usually occurs after an action and consequently they expect effects at the typical time of their occurrence and respond slower when an effect occurs earlier than expected (Haering & Kiesel, 2012). Similarly, causality judgments for delayed effects depend on whether participants experienced the same effect to occur immediately in a preceding block or not (Buehner & May, 2004).

Thus, the described studies observed that the effect of temporal contiguity on causal perception is modulated by expectations. However, in these studies causality judgments were only assessed at the end of a block and participants were asked to judge the estimated mean causality in the preceding block. The aim of the current study was to examine the effect of temporal contiguity and expectations on sense of agency judgments that were assessed after each trial. We conjecture that prediction processing detailed in predictive forward models, assumed to underlie sense of agency judgments (e.g., Haggard, 2005), have more impact on immediate, trial-by-trial judgments than on judgments given after one block of observations. Consequently, it is an open question whether sense of agency depends on temporal contiguity or is modulated by experience that effects usually occur delayed rather than immediately. To address this question, we split participants into two groups. The experimental group, the *delay group*, was adapted to an action-effect delay of 250 ms. The control group, the *immediate group*, was adapted to an immediate effect. In both groups, we assessed sense of agency in test blocks in which effects occurred after different delays ranging between 0 ms and 250 ms. We chose a virtual instead of a physical environment with a new computer-game like task so that participants' a priori expectations were minimal. Additionally, we did not inform participants about the delays between actions and effects.

In this setup, two opposing hypotheses can be tested (see Fig. 1). According to the contiguity hypothesis (our null hypothesis), participants are expected to sense less control the longer the delay and this pattern of results should be independent of experimental group. Thus, despite prior experience that usually effects occurred either after a constant delay of 250 ms or immediately after the action, sense of agency should not differ between both conditions, but decrease with temporal delay. In contrast, the experience hypothesis suggests that participants' sense of agency judgments should depend on prior experience and expectations. Participants should sense less control the more their previously built temporal expectations are violated (e.g., Sato, 2009), that is, the more the current delay deviates from the usually experienced delay. Please note that this hypothesis predicts the same pattern of results for the immediate group as the contiguity hypothesis. Yet, for the delay group, the experience hypothesis predicts control judgments to be smallest when effects occur immediately after the action and increase up to a maximum after 250 ms.

2. Method

2.1. Participants

36 participants (9 male, mean age 25 years) took part for 3 Euros or course credit. Two participants were left-handed, but all indicated to use the mouse with the right hand.

2.2. Apparatus and stimuli

The experiment was run with E-Prime (Schneider, Eschman, & Zuccolotto, 2002) on a PC with a 17″ CRT monitor. Acoustic stimuli were presented with VicFirth SIH-1 isolation headphones. Responses were collected with an optical computer mouse used with the right hand. On the screen "Edgar the moose" was presented with a red circle (3.7 cm) as its nose at the center of the screen. Clicking Edgar's nose resulted in a 50 ms tone that sounded like a moose bellowing. For control judgments in test blocks the moose disappeared and a rating scale (see Fig. 2) was presented.

2.3. Design and procedure

Participants completed adaptation blocks and test blocks. Each trial started with a fixation cross (1.6 cm) presented centrally for 500 ms within the target area, Edgar's nose. Then the mouse cursor appeared 9.7 cm left of the center of the screen. Participants were instructed to move the cursor to the target area and then to press the left mouse key as fast as possible.

In adaptation blocks, Edgar bellowed after each click on the target either immediately (immediate group) or with a delay of 250 ms (delayed group). After 1000 ms the next trial started. Target missed clicks resulted in an error sound and a written error message ("Daneben! Bitte klicke nur auf die Nase!", German for "Missed! Please only click on the nose!"). When no click was recorded within 1000 ms, participants were asked to respond faster ("Bitte schneller!", German for "Faster, please!"). In both cases, the cursor disappeared and the trial restarted with the fixation cross.