NeuroImage 76 (2013) 125–133

Contents lists available at SciVerse ScienceDirect

NeuroImage

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

How initial confirmatory experience potentiates the detrimental influence of bad advice

Markus R. Staudinger *, Christian Büchel

Department of Systems Neuroscience, Center for Experimental Medicine, University Medical Center Hamburg—Eppendorf, Hamburg, Germany

ARTICLE INFO

Article history:
Accepted 28 February 2013
Available online 15 March 2013

Keywords:
Advice
fMRI
Primacy effect
Reinforcement learning
Willingness to pay
Ventral pallidum

ABSTRACT

In everyday life, expert advice has a great impact on individual decision making. Although often beneficial, advice may sometimes be misleading and cause people to pursue actions that entail suboptimal outcomes. This detrimental effect may diminish over time, when individuals have gathered sufficient contradicting evidence. Given the strong influence initial information has on opinion and personality impression formation, we aimed to investigate whether initial advice-confirmatory experience potentiates the rigidity with which persons stick to misleading advice. Furthermore, we intended to characterize the neuronal basis of such putative primacy effect. While undergoing functional magnetic resonance imaging (fMRI), participants selected between probabilistically reinforced symbols and were given the misleading tip that two low-probability symbols had a high reinforcement probability. One of these symbols initially received manipulated advice-congruent positive feedback (PF), the other one advice-incongruent negative feedback. Behaviorally, participants were impaired at learning to avoid advice-receiving symbols and overvalued them in terms of willingness to pay (WTP) in an auction market. Crucially, initial PF potentiated all effects. Greater ventral pallidal response to initial but not later PF during learning predicted higher behavioral WTP. Our results demonstrate that the nature of the very first advice-related experience already determines how strongly misleading advice will influence learning and ensuing decision making—an effect that is mediated by the ventral pallidum. Thus, in contrast to conventional reinforcement learning, learning under the influence of advice is susceptible to primacy effects. The present findings advance our understanding of why false beliefs are particularly difficult to change once they have been reinforced.

Introduction

In our everyday life, we aim to identify actions that are followed by rewards. Learning about such environmental contingencies can come in different ways. We may learn via personal experience of reward and punishment (trial-and-error learning). However, in many instances, following advice is a faster and less costly strategy of determining preferable actions (Bandura, 1977; Biele et al., 2009; Engelmann et al., 2009). Such a strategy carries an inherent risk though. Sometimes advice—like instructions and rules—produces inflexible, rigid patterns of behavior that are insensitive to actual environmental contingencies (Hayes, 1993). For instance, after having received one-time misleading (i.e., bad) advice, agents adhered to recommended actions although they led to far less optimal outcomes than unexplored, alternative ones (Doll et al., 2009, 2011). Skinner suggested that advice has that effect because it specifies contingency expectations (Skinner, 1966), causing individuals to seek out and favor advice-confirming information, the so-called confirmation bias (Nickerson, 1998; Plous, 1993), and to dismiss any evidence to the contrary.

Although bad advice can exert a long-lasting detrimental influence on learning, behavioral rigidity may diminish over time, when individuals have gathered sufficient advice-contradicting evidence. Does it play a role when the first contradicting evidence is coming in? More precisely, does the character of the very first advice-related experience—which could be advice-congruent or -incongruent—already determine how rigidly a person will stick to bad advice? Social psychology research has demonstrated that primary information disproportionately influences both opinion and personality impression formation (Anderson and Barrios, 1961; Crano, 1977; Cromwell, 1950; Jones et al., 1968)—an effect termed the law of primacy in persuasion. For instance, Lund (1925) observed that the first of two opposed arguments on a controversial topic is more effective in changing individuals' attitudes. Stone (1969) in turn showed that in role play lawsuits primary testimonies affect jurors' final verdicts to a greater degree than later testimonies. In view of this, primary experiential information could be expected to also influence how strongly bad advice impacts learning. Initial confirmatory experience might reinforce advice-induced a priori beliefs to such a degree that advice-following behavior becomes resistant to

* Corresponding author at: Department of Systems Neuroscience, University Medical Center Hamburg—Eppendorf, Martinistr. 52, 20246 Hamburg, Germany. Fax: +49 40741059955.

E-mail address: m.staudinger@uke.de (M.R. Staudinger).

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http://dx.doi.org/10.1016/j.neuroimage.2013.02.074

change. Initial advice-contradicting experience, however, might entail a discounting of the misleading advice and a change in action policy.

Our aim in the present study was to investigate whether initial advice-confirmatory experience potentiates the detrimental influence of misleading advice on learning and decision making. Furthermore, we intended to characterize the neuronal basis of such putative primacy effect on advice. While undergoing fMRI, participants were repeatedly presented with four fixed pairs of probabilistically rewarded Japanese Hiragana symbols (Fig. 1A) (Frank et al., 2004). In each pair, one symbol had a higher probability of being correct (60%) than the other (40%). Volunteers had to learn to select the symbol with the higher probability via trial-and-error. Critically, before entering the scanner, participants were given the misleading tip that two of the four 40% symbols—symbols D and H—possibly had the highest probabilities of being correct among all symbols. To investigate the effect of initial advice-confirmatory experience, we manipulated the reinforcement feedback during the first three trials in all four pairs. Crucially, while choosing the advice-receiving symbol H was definitely correct during the first two trials and incorrect in the third (initial advice-congruent condition), choosing the other advice-receiving symbol D was incorrect in the first two trials but correct in the third (initial advice-incongruent condition). The feedback for the no-advice 40% symbols B and F was manipulated in a similar way so that they could serve as control symbols. After the third trial, feedback became probabilistic. Subsequently, outside the scanner, participants completed a test task where they saw all possible combinations of symbols and had to choose in the absence of reward feedback (Fig. 1B). Afterwards, for each symbol, volunteers completed a Becker–DeGroot–Marschack (BDM) auction (Becker et al., 1964) where they bid on a lottery ticket whose probability to win €8 equaled the probability specified by the displayed symbol (Fig. 1C). These BDM auctions enabled us to determine symbol-specific willingness to pay (WTP) values (Chib et al., 2009; Plassmann et al., 2007). Finally, participants completed a second fMRI session where they made purchase decisions for such lottery tickets at predetermined prices.

We hypothesized that one-time misleading advice results in suboptimal choice preference of advice-receiving 40% symbols D and H over 60% symbols during learning and test (Doll et al., 2009, 2011) as well as in higher WTP values of D and H as compared to the no-advice 40% symbols B and F. Critically, we expected early positive reinforcement to potentiate these effects: initial, positive, advice-congruent feedback should result in poorer performance on H than on D throughout the experiment, but entail no performance difference between control symbols F and B.

Previous studies have implicated the ventromedial prefrontal cortex (vmPFC), putamen, caudate, nucleus accumbens (NAcc) (Biele et al., 2011; Jocham et al., 2011; Li et al., 2010), and NAcc-downstream

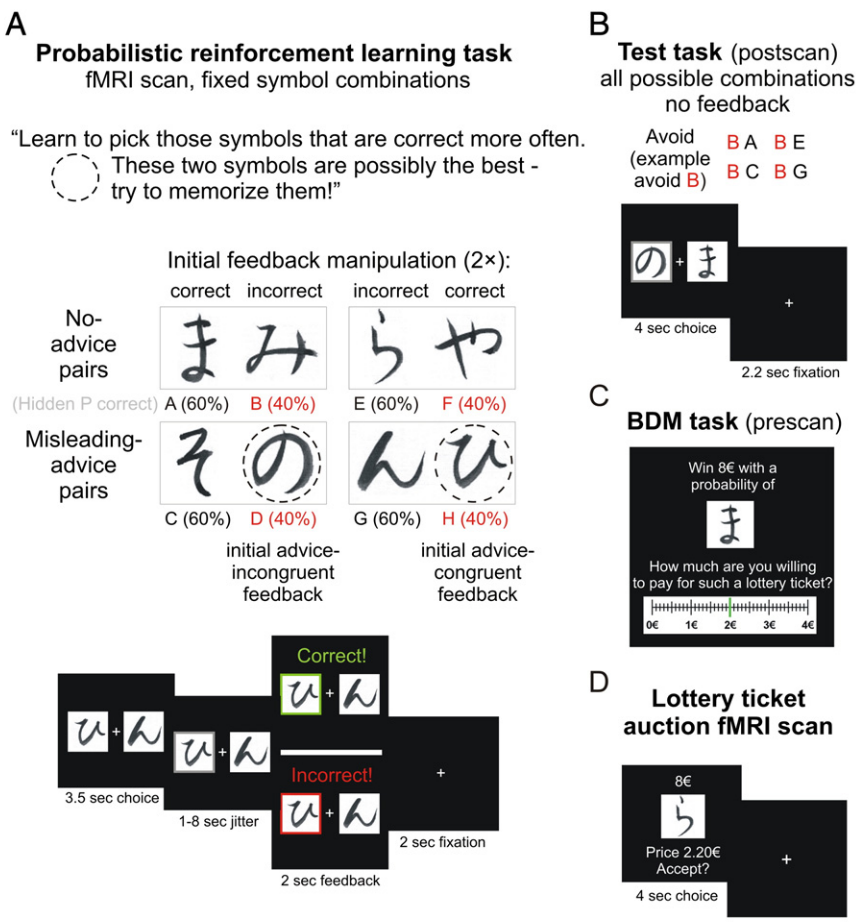

Fig. 1. Experimental design. (A) Probabilistic reinforcement learning fMRI session. Participants were repeatedly presented with four fixed pairs of probabilistically rewarded symbols (Hidden P: 60% vs. 40%) and had to learn to choose the symbol with the higher probability. Before entering the scanner, participants were given the misleading tip that symbols D and H possibly had the highest probabilities of being correct. Feedback during the first three trials was manipulated in all four pairs. Crucially, choosing H was definitely correct during the first two trials and incorrect in the third (initial advice-congruent feedback), choosing D was incorrect in the first two trials but correct in the third (initial advice-incongruent feedback). (B) Test task. Participants were presented with all possible combinations of symbols and had to choose in the absence of feedback. A high percentage of avoid decisions (preferring 60% symbols when being paired with 40% symbols) indicates successful learning. (C) BDM task. Participants bid on lottery tickets whose probabilities to win €8 equaled the objective learning phase probabilities of the displayed symbols, enabling us to measure symbol-specific WTP. (D) Lottery ticket auction fMRI session. Again, participants made purchase decisions for lottery tickets, only at predetermined prices (equal to the median WTP of all symbols ±€0.10), allowing us to determine neural correlates of WTP.