Video demonstrations seed alternative problem-solving techniques in wild common marmosets

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Studies of social learning and tradition formation under field conditions have recently gained momentum, but suffer from the limited control of socio-ecological factors thought to be responsible for transmission patterns. The use of artificial visual stimuli is a potentially powerful tool to overcome some of these problems. Here, in a field experiment, we used video images of unfamiliar conspecifics performing virtual demonstrations of foraging techniques. We tested 12 family groups of wild common marmosets. Six groups received video demonstrations (footage of conspecifics either pulling a drawer open or pushing a lid upwards, in an ‘artificial fruit’); the other six groups served as controls (exposed to a static image of a conspecific next to the fruit). Subjects in video groups were more manipulative and successful in opening the fruit than controls; they were also more likely to use the technique they had witnessed and thus could serve as live models for other family members. To our knowledge, this is the first study that used video demonstrations in the wild and demonstrated the potent force of social learning, even from unfamiliar conspecifics, under field conditions.

1. Introduction

Behavioural traditions and cultural phenomena were once thought to be distinctive to humans, but evidence for the social transmission of information and its maintenance over time and/or generations has now accumulated in a variety of non-human animals [1–8]. These studies have extended our understanding of social learning, traditions and the role of social dynamics in influencing the pattern and speed of information transmission under field conditions. However, little is known about the extent to which social learning is dependent on individual identity or group membership [6–7] or whether it can be elicited by any conspecific.

To control or manipulate these social factors, virtual stimuli offer considerable flexibility and are a potentially powerful tool for such social learning research [9]. Recent primate studies [10–13] successfully used video demonstrations to investigate the transmission of techniques in problem-solving tasks under laboratory conditions, but this approach has not been applied in the field, despite its potential to control for various factors such as the identity of the demonstrator, its group membership and motivational state. This study explored the applicability of videos as virtual demonstrations in wild common marmosets, Callithrix jacchus. We tested whether monkeys exposed to video demonstrations of unfamiliar individuals would show a higher motivation to forage at an ‘artificial fruit’ and a higher probability of showing the opening technique witnessed than control groups.
2. Material and methods

(a) Study site and subjects
The study was conducted between February and June 2010 in a fragment of Atlantic Forest in Aldeia, Pernambuco, Brazil, on 12 habituated family groups of wild common marmosets ($n = 108$; see the electronic supplementary material for further details and tables S1 and S2).

(b) Experimental set-up
The apparatus (‘Drawian fruit’) could be opened either by pulling a drawer open or by pushing an adjacent lid upwards to reach a reward (figure 1a,b). For the video footage, two captive middle-ranked adult marmosets (male and female) were each trained on one technique. The 5-min video for each technique showed 25 successful manipulations of the fruit (several actions from slightly different angles). All actions represented a close-up view of the model and the apparatus, without any cage elements visible. We presented the videos on a 15” LCD laptop screen, positioned within an opaque plastic box on a platform (figure 1c,d; electronic supplementary material, figures S1 and S2). All marmosets were fully habituated to the set-up and routinely visited the platform for feeding. When the Drawian was presented, it was placed in front of the window of the box at a similar angle to that shown in the video (figure 1d).

(c) Experimental conditions
The 12 groups were randomly assigned either to the video (lid or drawer) or control condition (table 1). The six video groups each received 17 sessions (two initial observation sessions with video only and 15 experimental sessions with the Drawian). Subjects could watch one video demonstration per experimental session, except for sessions 8–12, in which only a static image of a conspecific next to the apparatus was shown to increase the likelihood of directing the attention away from the video towards the apparatus. The six control groups each received 15 sessions with the static image condition only while they simultaneously had access to the Drawian.

(d) Data analysis
To analyse possible temporal differences, we divided test blocks into three sections corresponding to sessions 3–7, 8–12 and 13–17, respectively (table 1). We measured two main behavioural variables: (i) whether an individual was in proximity to the apparatus (within 1.5 m) and (ii) whether it was manipulating it. For both variables, we used one-zero scan sampling every 10 s within a time frame of 5 min, resulting in 30 score points per individual and session (see the electronic supplementary material for further details). We calculated the number of counts of (i) being in proximity and (ii) manipulations for each test block per individual. We ran generalized linear mixed models following a negative binomial distribution to investigate the impact of the fixed predictor variables condition, age, sex, test block and demonstrator sex on the dependent variables, the number of counts of (i) being in proximity and (ii) manipulations. No offset was required to model proportions here because the totals were equal in each case. Group and individual identity were entered as random factors. We performed a stepwise model selection by using Akaike’s information criterion to select the

Figure 1. Drawian ‘artificial fruit’ and experimental set-up. Video stills illustrate (a) pulling and (b) pushing. (c) Videos/static images were presented on a laptop screen placed in a plastic box on a platform. (d) During test sessions, the Drawian was positioned in front of the video box.

Table 1. Study design. Test sessions offering the Drawian were divided into three blocks for trials 3–7, 8–12 and 13–17, respectively.

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Table 2. Successful manipulations. In sessions indicated with a letter, at least one individual successfully opened the apparatus with either pushing the lid (L) and/or pulling the drawer (D). Bold letters: the successful technique matched the technique shown in the video; italic letters: the alternative technique was used. \( N_{\text{ind}} \) represents the number of successful individuals within the respective group.

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best model. For clarity and economy, we present only significant results (see the electronic supplementary material, table S4, for full models). Finally, we used non-parametric tests to assess whether the number of successful manipulations made by each subject varied between conditions.

3. Results

(a) Proximity to experimental apparatus

Marmosets in the video and control conditions did not differ significantly in the estimated proportion of time spent in proximity (electronic supplementary material, tables S2, S3 and S4). Juveniles and infants spent a greater proportion of time close to the experimental set-up than adults and subadults (Wald test: nsubjects = 91, Z = 3.43, p < 0.001). A significant effect of test block revealed a decrease in the proportion of time in proximity over time (block 2: Z = −3.45, p < 0.001; block 3: Z = −4.76, p < 0.001). There was no significant interaction between age and condition and no significant effect of sex or demonstrator sex.

(b) Manipulations

Overall, the two conditions differed significantly in the estimated proportion of time spent manipulating the task, with higher proportions in groups of the video condition (Wald test: nsubjects = 84, Z = 2.51, p = 0.012). A significant effect of test block revealed a decrease in the proportion of time spent manipulating over time (block 2: Z = −4.48, p < 0.001; block 3: Z = −6.77, p < 0.001). Sex and demonstrator sex did not have an influence, but age did (juveniles: Z = 3.77, p < 0.001) (electronic supplementary material; tables S2, S3 and S4).

(c) Successful manipulations

Twelve out of 84 individuals (14.3%) were successful at least once in manipulating the Drawian, opening either the drawer or the lid. There were successful individuals (n = 11) in 5/6 video groups versus just 1/6 control groups (n = 1) and this difference was significant (Mann–Whitney U-test, U = 4.5, p = 0.02). Similarly, video and control groups also differed in the number of openings (U = 5.5, p = 0.033; table 2 and figure 2). Crucially, successful individuals used more often the technique matching to the video (one-tailed Wilcoxon matched-pairs test: Z11 = −1.774, p = 0.038). When focusing on the ratios of matches and non-matches for only the four individuals who performed more than two manipulations irrespective of type (20/0, 5/1, 4/1 and 16/0), a significant tendency to match whichever of the two techniques was also seen (Z4 = −1.826, p = 0.034). In 4/5 successful video groups, (groups A, C, K and P), the first successful manipulation matched the technique shown in the video.

4. Discussion

Wild marmosets with access to video demonstrations of how to open an artificial fruit showed more manipulations of the task and a higher probability of solving it, typically with the technique observed, than did a control group who experienced the same set-up but could only witness a static image of a conspecific next to the apparatus. These results are in line with laboratory studies on marmoset social learning [12] and provide evidence that social information transmission occurs even with two-dimensional images of unfamiliar conspecifics.

The similar proportion of time spent in proximity in both conditions indicates that marmosets in the video condition were not merely more attracted to the set-up. They clearly differed from controls in the proportion of time spent manipulating the apparatus, suggesting that seeing a video of a conspecific manipulating and feeding out of it had a positive effect on their motivation to manipulate the object themselves. The observed effect of age might be explained by different levels of motivation or rewarding feedback with juveniles remaining more interested in the novel artificial fruit itself than adults [14].

A higher motivation to interact with the artificial fruit may have led to a higher probability of successes in individuals of the video groups but the opening technique was not chosen randomly. Instead, marmosets performed predominantly those actions demonstrated in the videos, suggesting they assimilated specific information, like where to handle the fruit (drawer or lid) or what to do (pulling or pushing). Further studies are needed to clarify whether these effects can also be elicited without a conspecific demonstrator (in a ‘ghost’ control where the manipulandum is moved automatically without influence from a demonstrator) and which of the potential
learning mechanisms (e.g. facilitation and enhancement) may best explain these results.

Owing to the group setting, we do not claim that all successful individuals learned solely from the videos; they may have been influenced by manipulations of other conspecifics or extracted the needed information from a combination of both [10]. However, few marmosets managed to solve the task within the study period, which stands in contrast to the time needed until success for most subjects in another social learning study in the same population [15]. It is likely that the current task was more physically demanding for callitrichids and/or individuals had problems with dividing their attention between the video and the artificial fruit (with or without live conspecifics).

This study is the first to show that video demonstrations are useful as a means to seed alternative problem-solving techniques under field conditions and adds to the small but rising corpus of experimental studies revealing social learning in the wild [1,3–8,15]. The fact that marmosets can learn from two-dimensional images of unfamiliar conspecifics underlines the potent force of social learning in primates, i.e. that individuals may learn from any skilled model, even a virtual conspecific. Our approach opens up a range of possibilities for experimentally introducing behavioural traditions and studying the basis of culture in non-human animals.

References