# Visible spatial contiguity of social information and reward affects social learning in brown capuchins (Sapajus apella) and children (Homo sapiens)

Lara A. Wood and Andrew Whiten

This is the accepted manuscript © 2017, APA. This article may not exactly replicate the final version published in the APA journal. It is not the copy of record.

The published article is available from: http://www.apa.org/pubs/journals/com/

1	Visible spatial contiguity of social information and reward affects social learning in
2	brown capuchins (Sapajus apella) and children (Homo sapiens)
3	
4	Lara A Wood <sup>1, 2</sup> & Andrew Whiten <sup>1</sup>
5	<sup>1</sup> University of St Andrews, <sup>2</sup> University of Abertay
6	
7	<sup>1</sup> Centre for Social Learning and Cognitive Evolution, and Scottish Primate Research Group,
8	School of Psychology & Neuroscience, University of St Andrews, KY16 9JP
9	<sup>2</sup> Division of Psychology, Abertay University, Dundee, DD1 1HG
10	
11	E-mail: <u>lanw@st-andrews.ac.uk</u> (corresponding author)
12	Author Note: This work was supported by a John Templeton Foundation grant ID 40128
13	awarded to A Whiten & K Laland.
14	
15	Acknowledgements
16	This research was undertaken at Edinburgh Zoo and we thank The Royal Zoological Society
17	of Scotland, their employees based at Budongo and Living Links, and the visitors for their
18	cooperation. Thank you to Hugo Jeffries for assistance with the child study and a volunteer
19	research assistant for inter-rater coding, Lewis Dean, Samantha Allan, and Alison Milne for
20	coding, and Keith Haynes for manufacture of the apparatus. Thank you to the editor and
21	reviewers for their helpful comments.
าา	

23

#### Abstract

24

Animal social learning is typically studied experimentally by the presentation of artificial 25 foraging tasks. Although productive, results are often variable even for the same species. We 26 present and test the hypothesis that one cause of variation is that spatial distance between 27 rewards and the means of reward release causes conflicts for participants' attentional focus. 28 We investigated whether spatial contiguity between a visible reward and the means of release 29 would affect behavioral responses that evidence social learning, testing 21 brown capuchins 30 (Sapajus apella), a much studied species with variant evidence for social learning, and 180 31 two- to four-year old human children (Homo sapiens), a benchmark species known for a 32 33 strong social learning disposition. Participants were presented with a novel transparent apparatus where a reward was either proximal or distal to a demonstrated means of releasing 34 it. A distal reward location decreased attention towards the location of the demonstration and 35 impaired subsequent success in gaining rewards. Generally, the capuchins produced the 36 alternative method to that demonstrated whereas children copied the method demonstrated. 37 although a distal reward location reduced copying in younger children. We conclude that 38 some design features in common social learning tasks may significantly degrade the evidence 39 40 for social learning. We have demonstrated this for two different primates but suggest that it is a significant factor to control for in social learning research across all taxa. 41

- 42
- 43 Keywords: Social learning mechanisms, Attention, Spatial contiguity

# 44 Visible spatial contiguity of social information and reward affects social learning in 45 brown capuchins (*Sapajus apella*) and children (*Homo sapiens*)

46

47 The formation of social traditions and culture in animal societies relies on the social transmission of information among individuals in a group. Many cognitive mechanisms exist 48 that might facilitate the transmission of information from one individual to another (Heyes, 49 1994; Whiten, Horner, Litchfield, & Marshall-Pescini, 2004) and understanding these 50 mechanisms is integral to understanding species differences in cultural abilities. Whiten et 51 al's. (2004) taxonomy of social learning mechanisms in primates details a plethora of ways 52 in which social learning might occur with different mechanisms involving differing levels of 53 54 cognitive complexity. For example, Whiten et al. (2004) define *imitation* as copying the form of an action (model movement centred), object movement re-enactment as copying the 55 form of a caused object movement (object movement centred), and end-state-emulation as 56 copying only the end or outcome of an action sequence (outcome centred). Refinements in 57 empirical methods and experimental tasks have aided the identification of social learning and 58 the corresponding mechanisms. One key experimental tool is artificial foraging apparatuses, 59 with two-action apparatuses offering a powerful design for measuring social learning. First 60 implemented by Dawson and Foss (1965) with budgerigars, these apparatuses offer two or 61 more means of accessing a reward (henceforth shortened to *means*) held within a defense 62 component that may occur in natural foods such as shelled fruits and insects within nests. 63 Control subjects are given such a task without any social information. Their behavior serves 64 as a baseline and is compared to other individuals' behavior following observation of either 65 of the alternative approaches. Social learning can be evidenced by increased levels of 66 success, decreased latency to success, or matching the means demonstrated. 67

68 In the last decade such apparatuses have been used in taxa from birds (Alpin et al., 2015) to meerkats (Thornton & Malapert, 2009), primate species including chimpanzees 69 (Whiten, Horner, & de Waal, 2005), squirrel monkeys (Claidière, Messer, Hoppitt, & 70 Whiten, 2013), vervet monkeys (van de Waal, Renevey, Favre, & Bshary, 2010) as well as 71 72 human children (Horner & Whiten, 2005) and adults (Flynn & Smith, 2012). However, within- and cross-species comparisons of social learning can be elusive due to variation in 73 the different apparatuses' manifestations, which can vary in their (1) means (2) degree of 74 transparency, (3) model type, and (4) efficiency (see Figure 1 for an illustration of these 75 differences). Thus, identifying the copying of a model's movement ('imitation'; Whiten & 76 77 Ham, 1994) may be restricted to tasks where the same component is moved but by different 78 model actions (Figure 1(1c)), or through the use of a ghost condition (Figure 1(3b) e.g., Hopper, Lambeth, Schapiro, & Whiten, 2008). Given the theoretical assertion that 79 mechanisms such as imitation may be unique to humans (Tomasello, 1996), it is important 80 that the social learning capabilities of each species are correctly identified. 81 For some species the evidence for social learning capabilities is still extremely 82 variable. For example, capuchins (Cebus and Sapajus genus) belonging to the Cebidae 83 family display strong social bonds, tool-use in the wild, and evidence of complex social 84 85 traditions (Fragaszy, Visalbergi, & Fedigan, 2004; Perry et al., 2003; Perry, 2011) and yet huge variation exists in experimental evidence for social learning in this genus (e.g., Dindo, 86 Thierry, de Waal, & Whiten, 2010 versus Fragaszy & Visalberghi, 1989). Here we explore 87 the hypothesis that some of these differences have been caused by variations in the 88 apparatuses presented, specifically in regard to the spatial contiguity of the reward, the 89 means, and the consequent social information as it affects the means. Capuchins' natural 90 91 attentional disposition may direct them towards rewards, making them less attentive to important social information distal to these rewards. In the wild capuchins may be attracted 92

93 to, for example, a nut protected by an opaque defense (the shell). These elements, the nut and the shell, are directly proximal to each other. If a conspecific demonstrated breaking the 94 defense and acquiring the nut, for example by hitting the shell with a stone hammer, the 95 96 model's actions and the means (shell breaking) are also proximal. In contrast, the form of 97 some apparatuses is such that the reward is visible (the apparatus is transparent) and the means is not immediately proximal to the reward (Custance, Whiten, & Fredman, 1999; 98 Fragaszy & Visalberghi, 1989; Visalberghi, 1993). Accordingly, attention may be drawn to 99 the reward rather than to the social information, potentially impairing social learning. 100 Spatial contiguity has been long thought of as a factor affecting non-social 101 associative learning in animals. Proximal unconditioned stimuli (often a food reward) and 102 103 conditioned stimuli (akin to the means) aid conditioning and discrimination learning (Wasserman & Miller, 1997). Rhesus macaques, for example, fail to learn a series of pattern 104 of discrimination problem when required to make their instrumental response at a distal 105 location from the stimulus but are successful when the two are proximal (Polidora & 106 Fletcher, 1964). Similarly, two- and young three-year-old human children struggle to 107 understand a causal relationship between an action and an outcome when the two are distal, 108 but succeed when the two are proximal (Kushnir & Gopnik, 2007). Interestingly, three and 109 110 four-year-old children were successful in both conditions, suggesting a developmental shift in the understanding of a causal event distally located from an action. 111 Another factor that might decrease success in tasks that have a distal spatial 112

contiguity between means and rewards is prepotent responses to attend to and reach for food,
associated with a lack of inhibitory control. Capuchins, described as an impulsive species
(Fragaszy et al., 2004), have relatively poor inhibitory control as compared with other largebrained primates (Amici, Aureli, & Call, 2008). Task-naïve capuchins show little evidence
of self-control concerned with delay gratification (Beran et al., 2016) although with training

they can develop delay gratification and let lesser rewards pass them by in order to obtain
greater rewards (Bramlett, Perdue, & Evans, 2012). Furthermore, capuchins can also learn to
use a computer joystick where their actions (operating the joystick) are necessarily spatially
distal from the movement of the cursor (Evans, Beran, Chan, Klein, & Menzel, 2008).
Therefore, we might expect to see an improvement in performance over multiple trials and
phases when using distally presented rewards.

Taking such considerations into account in the context of social learning, we may 124 predict more learning in capuchins when the distance between reward and the action upon 125 the defense are proximal or unknown. Conversely, we would predict depleted evidence of 126 127 social learning when the reward and action upon the defense are visibly distal. Dindo, Thierry, de Waal, & Whiten (2010) created an opaque apparatus in which either one food 128 reward was baited behind a central door-defense that could be removed up, either diagonally 129 left or right (Experiment 1), or two food rewards each baited behind two defenses that could 130 be accessed by moving a slider up either diagonally left or right (Experiment 2). Copying of 131 the means (door left or right) was evident in Experiment 1 but relatively absent in 132 Experiment 2. The authors concluded that the different responses may have been due to the 133 capuchins prioritizing exploratory behavior when alternative foraging locations were 134 135 accessible. An alternative explanation is that the reward locations affected the capuchins' attention: in Experiment 1 attention was directed towards the reward behind the central door 136 and this door's movement was salient, whereas in Experiment 2 attention was directed 137 towards the rewards behind the two top defences and the central door movement was less 138 salient. Thus opacity of reward location may facilitate social learning. 139

Differences	Detail	Example	Description
(1) <b>means</b> of accessing reward	(a) different access points		One of two defenses is disabled (e.g., open door A versus door B).
	(b) same access but different components moved		The same defense is removed in one of two ways (e.g., door opens up versus door slides).
	(c) same component moved but different model actions		The model uses one of two methods to achieve the same movement (e.g., push using index finger versus pull using index and thumb).
(2) degree of <b>transparency</b>	(a) opacity in apparatus		The reward is not visible and potentially neither is some or all of the means of accessing reward.
	(b) transparency in apparatus		The reward is visible and potentially so are critical means of accessing reward.
(3) model	(a) animate	Î	The means of accessing reward is visibly achieved by an animate agent usually a conspecific or a human model.
	(b) mechanical		The means of accessing reward is achieved 'as if by a ghost' using invisible mechanisms (ghost condition).
(4) efficiency	(a) efficient	A	The means of accessing reward is achieved in an efficient way.
	(b) inefficient	A	The means of accessing reward is achieved in an inefficient way; some actions may be unnecessary to cause means.

Accepted in the Journal of Comparative Psychology on 12 April 2017

<sup>140</sup> Figure 1: Schematic overview of ways in which apparatuses can differ.

There are empirical examples of opaque defense configurations, such that the 141 distance between the reward and actions upon the defense are also opaque. Crast, Hardy & 142 Fragaszy (2010) created a task for tufted capuchins (Sapajus apella) involving opaque juice 143 dispensers offering two different methods of solution. Here, infants' learning was assisted by 144 the demonstration of successful juice extraction by adults. There was some evidence of 145 preferential copying of the specific method seeded although this was confounded by the 146 locking of the alternative method during a phase of the experiment. Dindo, Thierry, & 147 Whiten (2008) and Fredman & Whiten (2008) created a number of opaque apparatuses that 148 included a single defense that could be operated in either of two different ways and in both 149 150 studies there was significant matching to the method witnessed, possibly by emulation of the 151 means (e.g., lift door versus slide door). Fredman & Whiten (2008) included a study where humans demonstrated a tool-use behavior to human-reared capuchins. Here, some evidence 152 existed that capuchins copied the model's actions as well as the result. Fredman & Whiten 153 (2008) suggest that the enculturation experience of these capuchins may have elevated 154 cognitive processes to facilitate imitation or other relatively sophisticated social learning 155 mechanisms. However, differences in demonstration from humans versus conspecifics 156 cannot be discounted as explanations for the differences in learning between the human-157 158 raised and mother-raised capuchins.

In contrast to such opaque apparatuses, some studies have employed transparent tasks with a distal location between reward and actions upon the defense and these have elicited very little evidence of social learning. Fragaszy & Visalberghi (1989) presented two different apparatuses to two groups of tufted capuchins. Both apparatuses had visible rewards and required the use of tools. Several capuchins in each group learned to solve these problems but the analysis of conspecific observations and order of success did not provide any evidence of the capuchins learning about specific instrumental relations. Likewise,

Visalberghi (1993) presented six capuchin monkeys with sticks and a transparent, baited tube. Three spontaneously solved the task but the other three, despite opportunity to watch successful conspecifics, were not successful. Analysis of videos revealed that the capuchins did not selectively scrutinise the actions of the model while s/he solved the problem anymore than in non-demonstration periods. It should be noted that these tasks also required tool use which may have impacted success.

Custance et al. (1999) employed two versions of a transparent apparatus, 172 incorporating either a barrel or bolt latch, each of which could be opened with either of two 173 techniques consisting of two related actions. The reward was visible at the bottom of the 174 175 apparatus although it was not placed in a specific area (Fredman, personal communication) 176 and the defenses were situated at the top section of the apparatus. In the bolt latch task the capuchins used the demonstrated technique and the non-demonstrated technique at 177 equivalent frequencies and coders were unable to infer which technique the capuchins had 178 seen demonstrated. Likewise, the two techniques for the bolt latch were used at equivalent 179 frequencies irrespective of demonstration content, although here coders were able to infer 180 which technique had been demonstrated based on whether the capuchin's actions occurred in 181 the front or the back of the apparatus. 182

In summary, capuchin social learning has appeared most evident and sophisticated when the distance between reward and means were proximal or unknown. These findings support the hypothesis that visible contiguity between reward and social information affects social learning. The current study directly tested this hypothesis by systematically manipulating the proximity between a reward and the social information. We predicted that the location of the reward would affect capuchin performance on the task such that a reward that was distal, as opposed to proximal to the task, would: (a) reduce attention toward the

means as the capuchins would look significantly more at the reward; (b) reduce success and
latency to success; (c) reduce copying of demonstrated means.

192

#### 193 A comparative study with human children

194 We have focused the above analysis and the present study on capuchin monkeys 195 because our general hypothesis may explain the huge variability in evidence for social 196 learning in this genus. However, as previously discussed, effects of spatial continuity on 197 learning are evident in other animals. Here we chose to explore the issue further with a second primate species, humans. Human children are prolific social learners from infancy 198 199 (Carpenter, Akhtar, & Tomasello, 1998) and the importance of attention for children's social 200 learning has long been highlighted (Bandura & Walters, 1977). Children can provide a good comparative group for understanding phenomena relating to social learning because unlike 201 many captive primate populations one can access a large sample size allowing for: (a) 202 additional experimental conditions; (b) the study of a large sample, within a restricted age 203 204 period, to capture developmental changes in the phenomena of interest; (c) the inclusion of 205 additional control conditions excluding the demonstration of social information. The current 206 study involved 180 two- to four-year-old children alongside 21 capuchins.

207 In the last two decades there has been a surge of experiments with children utilizing foraging apparatuses, with stickers often replacing food rewards (e.g., Horner & Whiten 208 2005; Wood, Harrison, Lucas, McGuigan, Burdett, & Whiten, 2016). These apparatuses 209 210 have evidenced sophisticated social learning in children that extends to high fidelity copying 211 of demonstrator actions and results (Hopper, Flynn, Wood, & Whiten, 2010). For the current study two- to four-year-olds were selected as there are important developmental changes in 212 social learning mechanisms during these ages. For example, following video demonstrations 213 of the removal of a reward, situated 15cm behind an opaque defense, five-year-old children 214

faithfully copied all actions, whereas three-year-olds omitted significantly more of the
unnecessary actions (McGuigan, Whiten, Flynn, & Horner, 2007). Exploring the effect of
spatial contiguity in a similar apparatus should inform our understanding of the impact of
distracting rewards upon social learning.

219 Development of children's cognitive skills may affect their attention to reward, rather than means. For example, four-year-olds show substantially more settled and focused 220 attention than two-year-olds (Anderson & Levin, 1976; Ruff & Capozzoli, 2003). They can 221 therefore focus on multiple stimuli and be less distracted by other attractive stimuli. Ruff & 222 Capozzoli (2003) suggest inhibitory control processes were present in the older, but not the 223 224 younger, children. Indeed, there is a significant increase in children's inhibitory control 225 abilities from two- to four-years-old (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). We tested 60 children on their response to the apparatus without showing them social 226 information to ascertain a baseline of success (we also did this for two male capuchins that 227 would not isolate). Half of the control children were presented with the task with the reward 228 229 and means distally located, half with them proximally located. We predicted less success and greater latency to success for children in the distal as opposed to the proximal condition. For 230 the 120 children that watched demonstrations we predicted that, as with the capuchins, a 231 232 reward that was distal, as opposed to proximal, to the means would: (a) reduce attention toward the means as the children would look significantly more at the reward; (b) reduce 233 success and latency to success; (c) reduce copying of the demonstrated means. Further, in 234 235 line with improvement in attention and inhibitory control, we predicted that this effect would be least pronounced in the older children. 236

238

#### **Experiment 1: Capuchins**

#### 239 Study site and participants

Participants were housed at the Living Links to Human Evolution Research Centre, 240 based within the Royal Zoological Society of Scotland's Edinburgh Zoo, UK (Leonardi et al., 241 2010; MacDonald & Whiten, 2011). Accordingly, all procedures were approved by the Royal 242 Zoological Society of Scotland as well as the Ethics Committee of the University of St 243 Andrews' School of Psychology. Procedures were conducted in accordance with the 244 guidelines of the Association for the Study of Animal Behaviour. The Centre houses two 245 mixed species communities of common squirrel monkeys (Saimiri sciureus) and brown 246 247 (tufted) capuchin monkeys (Sapajus apella) in two neighboring enclosures. At the time of the 248 experiment, there were nine adult males, seven adult females, seven sub-adults, six juveniles and six infants. The groups were housed in similar enclosures comprised of a 900m<sup>2</sup> outdoor 249 250 area containing vegetation and a 189m<sup>3</sup> indoor enclosure. The monkeys have 24 hour indoor and outdoor access (excepting inclement weather) including access to an off-exhibit indoor 251 area. The monkeys are given a rich diet of meat, eggs, fruit, vegetables and TrioMunch 252 pellets and have access to water *ad libitum* except for periods of voluntary isolation in the 253 research cubicles, which involve a maximum of two 15 min periods on four days of the week. 254 255 Most of the monkeys are habituated to remain in the research cubicles for research 256 sessions by themselves. Entrance into the research cubicles is voluntary and a monkey is never forced to come into the research cubicles. If a monkey shows any signs of distress 257 258 including ceasing participation, moving to the back of the cubicle, putting hands on the 259 cubicle slides and/or specific vocalisations, they are reintroduced to the group immediately. Rewards used in experiments are sunflower seeds, nuts, raisins, dates, cereal and 260 mealworms. Maximum allowances for these are specified by the husbandry team. 261

262	Participants aged over one-year-old (N $=$ 33) were invited into research cubicles
263	(described below). Of the thirty-three potential participants 22 animals voluntarily separated
264	to participate but three of these showed signs of anxiety during the demonstration phase and
265	so did not continue with the experiment leaving 19 capuchins that participated in the full
266	experiment. These capuchins ranged from three to 17 years-old. Nine capuchins (three
267	females, Mean age = $8.8$ (SD = $4.4$ ) years) were in the proximal condition and ten capuchins
268	(three females, Mean age = $6.5$ (SD = $3.3$ ) years) were in the distal condition. Two additional
269	adult males would not separate from the group but were able to monopolise the apparatus
270	and so participated at the end. They served as no-demonstration controls, receiving no
271	information before being given access to the task.
272	
273	Design
274	In a between-group design capuchins were systematically assigned, dependent on
274 275	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was
274 275 276	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins
274 275 276 277	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below,
274 275 276 277 278	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control
274 275 276 277 278 279	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject
274 275 276 277 278 279 280	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject variable of reward location.
274 275 276 277 278 279 280 281	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject variable of reward location.
274 275 276 277 278 279 280 281 282	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject variable of reward location.
274 275 276 277 278 279 280 281 282 282 283	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject variable of reward location. <b>Materials</b> A new apparatus was created for this experiment to meet three criteria not met in pre-
274 275 276 277 278 279 280 281 282 281 282 283 284	In a between-group design capuchins were systematically assigned, dependent on their age and sex, to one of two experimental conditions in which the food reward was placed in either a proximal (5cm) or distal (25cm) location relative to the means. Capuchins watched either a pull-cord or lift-platform method of reward retrieval as described below, counterbalanced across the experimental condition. Finally, as a quasi within-subject control the reward location was reversed in a second phase creating an additional within-subject variable of reward location. <b>Materials</b> A new apparatus was created for this experiment to meet three criteria not met in pre- existing apparatus: (a) the apparatus had two distinctly different means of accessing a single

and the means; (c) the reward would always be equidistant from the two means. The

287 apparatus (see Figure 2) was a transparent plastic cuboid case (l = 30cm, h = 10cm, d =8cm). Within the case there was a transparent platform situated 4cm from the top that ran the 288 length of the case. The platform was hinged so the platform could swing up like a flap. The 289 reward could be placed at either end of this platform. There were two means of acquiring the 290 reward. The first means was *pull-cord*: on the right-hand-side of the platform a cord was 291 threaded from the base of the platform to the top of the case and through a plastic knobble 292 which sat at the top of the box. Thus, when this knobble was pulled up, the cord pulled the 293 platform up, so the reward rolled off the back. The length of this cord prevented the platform 294 from rotating downwards. The second means was *lift-platform*: below the platform was a 295 296 3cm<sup>2</sup> square hole such that the platform could be pushed up from below, again making the 297 reward roll off the back. The released reward fell to the bottom of the front of the transparent case where there was a rectangular hole (1 = 26 cm, h = 2 cm) through which the reward 298 exited the case. At the back of the case was a door to allow re-baiting. 299

Testing took place in one of eight neighboring research cubicles (each approximately 300 301 50cm x 50cm x 50cm). At the front of each research cubicle was a window with six holes; one circular (d = 3cm) hole in the centre of the window where all rewards could be given by 302 the experimenter, and five holes corresponding with specific locations on the task when it 303 304 was flush against the window. These included a rectangular formation of four round (d = 305 3cm) holes: hole A in line with the knobble at the top of the task, just above food reward in proximal condition; hole B in line with the opening below the platform, just below food in 306 307 proximal condition; hole C same height as hole A but located 15cm away, just above food in distal condition; hole D same height as hole B but located 15cm away, just below food in 308 distal condition. The final hole was rectangular with the same dimensions as the exit and 309 lined up with this exit when the box was flush against the window. A Sony Handycam was 310

- positioned on a tripod behind the task facing towards the capuchins so that their behavior,
- including their responses and head and eye movements, could be video recorded.
- 313

Distal

Proximal



314

Figure 2. The test apparatus. The reward (highlighted by a white circle) was either distal

- 316 (left images) or proximal (right images) to the two means. The two means are highlighted by
- a black rectangle: (1) 'pull-cord' (top images): a plastic knobble joined to the platform by
- string. Pulling knobble causes the platform to rotate up, and the reward to fall from the back
- of the platform to the case exit; (2) 'lift-platform': a square hole in the front of the case.
- 320 Inserting finger through hole and pushing platform causes platform to rotate up, and the
- 321 *reward to fall from the back of the platform to the case exit.*
- 322

#### 323 **Procedure**

- 324 Capuchins were isolated opportunistically depending on cubicle entry and
- 325 willingness to isolate. Once isolated the capuchin was rewarded with a seed from each of
- four holes from which they could potentially access the task or attempt to access the food.
- 327 The trolley with the task was pulled to within 30cm of the front of the window so the
- 328 capuchin could see the task but not touch it. Once the capuchin was attending to the front the

experimenter said the capuchin's name while simultaneously holding up a reward just above 329 the centre of the task. The experimenter then baited the box, putting the reward in either a 330 proximal or distal location. Within two seconds the experimenter operated either the pull-331 cord or lift-platform method, such that the platform swung up and the reward fell out of the 332 apparatus and into a tray below, making it clear that the reward had been extracted. The 333 334 capuchins received 10 demonstrations. On demonstrations one, four, seven, and 10 the nut was taken from the tray and given to the capuchin through the central reward hole. These 335 reward intervals were selected to sustain interest and to indicate that they could receive the 336 reward. A peanut was not given after each trial to avoid satiation and exceeding the zoo's 337 recommend daily amounts (presuming the capuchin gained all rewards in the phase). 338 339 After the 10 demonstrations the experimenter re-baited the task in the same way and pushed the task forward until it was against the window and the session time of five minutes 340 started. If a capuchin was successful it was given up to a further four trials within five 341 minutes. Capuchins that were not successful were given much lower value rewards through 342 the central hole, including a sunflower seed every minute and two nuts at the end of the 343 session. This was to adhere to facility requirements of promoting isolation and participation 344 in the research cubicles. There was a second phase up to six days later with no 345 346 demonstrations. The reward was baited in the opposite end of the task for each capuchin. If the capuchin was successful it was given up to a further four trials if this fell within five 347

348 minutes.

349

350 Coding

Four people (two individuals unaware of the study's aims, one person not involved in the study but aware of the broad hypothesis, and the experimenter) separately coded visual attention for each of the ten trials at the point at which either the pull-cord or lift-platform

354	action was performed. Coders were separately asked to imagine a line in the middle of the
355	apparatus and judge, at the moment at which the platform was most raised and the reward
356	fell, whether attention was towards: (a) the left side of the box, where the means were
357	located (means); (b) at the right side of the box, away from the means (non- means); (c)
358	away from the box (away); or (d) unsure of where attention was focused (unsure). If fewer
359	than three coders agreed on a category, this was coded as unsure. All other behaviors were
360	coded by one of the individuals unaware of the study's aims and these included: (a) the side
361	of the box where the participant's hand first made contact with the box (First Touch: means
362	or non-means); (b) successful retrieval of the reward within the trial time (Success: yes or
363	no); (c) duration between the task being pushed flush to the cubicle window and the reward
364	exiting the box (Latency to success); and (d) how the reward was obtained (Means: pull-
365	string, lift-platform or other).
366	
366 367	Results
366 367 368	<b>Results</b> Table 1 summarises the participant allocation and main findings. The following
366 367 368 369	<b>Results</b> Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses.
366 367 368 369 370	<b>Results</b> Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses.
366 367 368 369 370 371	Results Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses. Attention towards means demonstrations
366 367 368 369 370 371 372	Results         Table 1 summarises the participant allocation and main findings. The following         sections provide details of statistical analyses of the main hypotheses.         Attention towards means demonstrations         Stepwise multiple regressions were conducted to evaluate whether visual attention
366 367 368 369 370 371 372 373	Results Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses. Attention towards means demonstrations Stepwise multiple regressions were conducted to evaluate whether visual attention during demonstrations could be predicted by the reward location and the age of the capuchin
<ul> <li>366</li> <li>367</li> <li>368</li> <li>369</li> <li>370</li> <li>371</li> <li>372</li> <li>373</li> <li>374</li> </ul>	Results Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses. Attention towards means demonstrations Stepwise multiple regressions were conducted to evaluate whether visual attention during demonstrations could be predicted by the reward location and the age of the capuchin (Table 2). The count of a capuchin's attention over the ten trials and the capuchin's age were
<ul> <li>366</li> <li>367</li> <li>368</li> <li>369</li> <li>370</li> <li>371</li> <li>372</li> <li>373</li> <li>374</li> <li>375</li> </ul>	Results Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses. Attention towards means demonstrations Stepwise multiple regressions were conducted to evaluate whether visual attention during demonstrations could be predicted by the reward location and the age of the capuchin (Table 2). The count of a capuchin's attention over the ten trials and the capuchin's age were entered separately for attention towards the means and non-means with age and reward
<ul> <li>366</li> <li>367</li> <li>368</li> <li>369</li> <li>370</li> <li>371</li> <li>372</li> <li>373</li> <li>374</li> <li>375</li> <li>376</li> </ul>	Results Table 1 summarises the participant allocation and main findings. The following sections provide details of statistical analyses of the main hypotheses. Attention towards means demonstrations Stepwise multiple regressions were conducted to evaluate whether visual attention during demonstrations could be predicted by the reward location and the age of the capuchin (Table 2). The count of a capuchin's attention over the ten trials and the capuchin's age were entered separately for attention towards the means and non-means with age and reward location as predictor variables. For both attention towards the means and non-means, the

location; with a distal reward location predicting a greater number of looks toward means (p < .001) and looks away from means (p < .01).

- 380
- 381 Effects of reward contiguity on success

Ten capuchins used pull-cord and eight capuchins used lift-platform for their first 382 success, indicating no bias towards either method (Binomial, p = .82, all non-parametric tests 383 are two-tailed). Three of the 19 capuchins, all in the distal condition (N = 10), were 384 unsuccessful. This 30% failure rate was not significantly different from the 0% failure rate of 385 those in the proximal condition (N = 9, Fisher's exact, p = .12). Latency to success was 386 387 investigated with unsuccessful capuchins given a latency of 300s (five minutes). A stepwise 388 linear regression was conducted to evaluate whether reward location and participant age were necessary to predict latency to success. At step 1 of the analysis reward location was 389 390 entered into the regression (B = 98.66, SE = 46.06, p < .05, F<sub>(1, 17)</sub> = 4.58, p < .05) accounting for 21.3% of the variance. Age did not enter into the equation (p = .36). 391 392

#### 393 Effects of reward contiguity on matching of demonstrated means

Twelve of the 16 successful capuchins used the alternative means to the one demonstrated (Binomial, p = .08). Eight of the nine capuchins in the proximal condition used the opposite means to the one demonstrated which was itself significant (Binomial, p < .05). Four of the seven successful capuchins in the distal condition used the opposite means to the one demonstrated which was not a significant difference (Binomial, p > .99).

						x attenda	nce:				
										x latency to	N copied
	Condition	Ν	N saw	Mean Age in	towards	toward non-	away	attendance	N successful	success in	demonstrated
		(Female)	pull-	months (SD)	means	means		unsure	(%)	seconds	means
			cord							(IQR)	
Capuchins with	Proximal	9 (3)	4	94.7 (53.9)	9	0	0	1	9/9 (100%)	9 (47)	1/9
demonstration	Distal	10 (3)	6	78 (45.4)	1	2	0	5.5	7/10 (70%)	75 (287)	3/7
Children with	Proximal	60 (30)	30	41.6 (10.4)	9	0	0	0	59/60 (98%)	8 (15)	57/59
demonstration	Distal	60 (30)	30	41.0 (10.8)	6	1	1	2	50/60 (83%)	15 (77)	41/50
Children without	Proximal	30 (15)		41.6 (9.9)					18/30 (60%)	70.4 (162)	
demonstration	Distal	30 (15)		41.8 (9.6)					8/30 (27%)	180 (39)	

#### **Table 1: Descriptive summary of participants and main results capuchins and children**

400 Note: Attendance to demonstrations (range of 0 to 10) and latency to success were not normally distributed ( $\tilde{x}$  = median).

401

#### 402 Table 2: Summary of simple regression analyses for variables predicting location of attention during demonstrations

	Capuchins							Children				
		Non- mea	ins		Means		Ν	lon- means	i		Means	
	В	SE B	β	В	SE B	β	В	SE B	β	В	SE B	β
Reward Location	-6.5	0.85	-0.88***	2.70	.84	0.62**	-1.80	0.29	-0.50***	2.95	0.45	0.51***
Age in years										0.06	0.02	0.20*
R <sup>2</sup>			.77			.38			.25			.30
F			58.16***			10.46**			39.88***			25.53***

403 Note: \**p* < .05. \*\**p* < .01. \*\*\**p*<.001. Reward location; proximal = 1, distal = 2

#### 404 Additional analyses of behavioral details

Table 3 presents descriptive statistics and below is a brief overview of the additional 405 analyses. Two capuchins that would not isolate had a reward baited in the proximal location 406 407 with no demonstration; one discovered pull-cord in 5s and the other discovered lift-platform in 2s. Including the two no-demonstration capuchins, the first touch of 20/21 capuchins 408 corresponded to the location of the reward (Binomial two-tail, p < .001). Participants could 409 participate in up to five trials in five minutes; 9/9 capuchins in the proximal condition had 410 411 five successes whereas only 5/10 capuchins in the distal condition completed five trials. In the second phase, when the location of the reward was reversed for each capuchin (proximal 412 to distal and vice versa), the majority once again touched the side of the task where the 413 414 reward was located, although six capuchins, originally in the proximal condition, touched the side congruent with the means. All previously successful capuchins were successful again. 415 Two of the three previously unsuccessful capuchins were successful when the reward was 416 moved from distal to proximal, both succeeding in 4s. The third capuchin did not interact 417 418 with the task. Eight capuchins used the same method throughout, seven of these used the pull-cord. The remaining twelve capuchins used both methods. 419

420

#### 421 Table 3: Descriptive summary of additional analyses (capuchins)

			Phase 2: Powar	x method choice over			
			Filase 2. Newai	ten trials			
	First touch	Five	First touch	Neucossful	$\tilde{x}$ difference in	Dull	l ift
Condition	proximal to	successes	proximal to	in Phase 2	latency T1-T6	String	Diatform
	means	trials 1 to 5	means	III Flidse Z	(IQR)	Sung	FIGUUITI
Proximal	11/11	11/11	5/11	11/11	-6 (51 3)	8 (4 5)	2 (4 0)
(N =11)	11/11	11/11	3/11	1 1/ 1 1	-0 (01.0),	0 (4.3)	2 (4.0)
Distal	1/10	5/10	0/0	0/10	14 5 (202 3)	5 (8 0)	2 (5 5)
(N = 10)	1/10	5/10	3/9	5/10	14.5 (202.5)	5 (0.0)	2 (3.3)

422 Note: Proximal condition includes two monkeys with no demonstration. Attendance to demonstrations

423 (range of 0 to 10) and latency to success were not normally distributed ( $\tilde{x} = median$ ).

425	Experiment 2: Children
426	Study site and participants
427	In total 193 two- to four-year-old children completed the study. Thirteen children
428	were excluded from analysis for various reasons (English not first language, technical
429	problems during experiment, or interference by caregiver). The remaining 180 children (90
430	females) ranged from 24 to 59 months ( $M = 41.4$ , $SD = 10.3$ ). Children were recruited while
431	visiting Edinburgh Zoo through a poster which read, "Aged 2 to 4? Win stickers!" Consent
432	was obtained from the child's caregiver, provided they were a parent or grandparent.
433	
434	Design
435	In a between-group design echoing the capuchin study, children were systematically
436	assigned, dependent on their age and sex, to one of two experimental conditions, with the
437	reward being placed in a proximal (5cm) or distal (25cm) location relative to the means.
438	Following the procedure of Experiment 1, 120 of these children watched ten demonstrations
439	of either the pull-cord or lift-platform method or reward retrieval. An additional 60 children
440	did not see any demonstration.
441	
442	Materials
443	The same apparatus was used, bolted to a small wooden table ( $l = 50$ cm, $h = 40$ cm, d
444	= 40cm). The reward within the apparatus was a plastic medal ( $d = 3$ cm) which was then
445	exchanged for an equal sized sticker. Testing took place in a designated child research room

446 at RZSS Edinburgh Zoo. There were two small chairs (h = 80cm) in the room; one in front of

447 the task (for the participant), and one by the entrance to the room (for the caregiver). The

448 camera and tripod were adjusted for the height of the child.

#### 450 **Procedure**

After obtaining written consent from the caregiver and verbal consent from the child, 451 the child and caregiver were invited into the research room. Additional members of the 452 child's visiting group were asked to remain outside. Children were asked to take a seat on the 453 chair in front of the task and the experimenter knelt down to be at a similar height to the 454 child. The table with the task was located within 20cm of the child. The experimenter held 455 up the medal and said, "If you get this, you get a sticker, let's start you a pile" and a sticker 456 was placed on the table. From here, the procedure was very similar to that of Experiment 1. 457 Once the child was attending to the front, the experimenter said the child's name while 458 459 simultaneously holding up the reward just above the centre of the task. The experimenter 460 then baited the task, putting the reward either in the proximal or distal location. Within two seconds the experimenter operated either the pull-cord or lift-platform such that the platform 461 swung up and the reward fell out onto the table, making it clear that the reward had been 462 extracted. The child received 10 demonstrations. On demonstrations one, four, seven, and 10 463 the experimenter picked up a sticker and added it to the child's pile. These reward intervals 464 were selected to sustain interest and to indicate that they could receive the reward, but a 465 sticker was not given after each trial to keep the reward administration similar to the 466 capuchins'. After the 10 demonstrations the experimenter rebaited the task in the same way 467 and said, "Now it's your turn." The session time of three minutes started. If children were 468 successful they were given up to a further four trials if this fell within the three minutes. The 469 children that were not successful were rewarded with a sticker every one minute and two 470 more stickers at the end of the session to keep in line with the procedure used with the 471 capuchins. Thus, they received the same number of stickers as successful individuals. There 472 was no second phase where the reward location was reversed. 473

474

475 Coding

476	A research assistant involved with the study and a second research assistant, blind to
477	the study's aims, separately coded eye gaze in the same way as for the capuchins: (a) the left
478	side of the box, where the means were located (means); (b) at the right side of the box, away
479	from the means (non- means'); (c) away from the box (away); or (d) unsure of where
480	attention was focused (unsure). If coders did not agree, it was coded as unsure. All other
481	behaviors were coded by a research assistant that was blind to the aims of the study and
482	included: (a) First Touch; (b) Success; (c) Latency to success; (d) Means. These were
483	defined in line with the capuchin study except latency to success was from when the reward
484	was baited and the baiting door closed until the reward exited the box.
485	
486	Results
487	Table 1 summarises the participant allocation and main findings. The following
488	sections provide details of statistical analyses of the main hypotheses.
489	
490	Attention towards means
491	The same stepwise multiple regressions as for the capuchin study were conducted to
492	evaluate whether attending during demonstrations could be predicted by the location of the
493	reward and the age of the child (Table 2). For attention toward means the only model
494	accounting for significantly more variance than no predictors included both reward location
495	and age ( $p < .001$ ). For attention toward non-means the only model accounting for
496	significantly more variance than no predictors included location ( $p < .001$ ) and did not
497	include age.
498	
499	Effects of reward contiguity on success

Overall, 135/180 individuals were successful in the three minutes; 68 children used 500 pull-cord and 61 children used lift-platform, indicating no bias towards either method 501 (Binomial two-tailed, p = .59). Six used an alternative method of reaching their hand through 502 the exit slot and tipping the platform from this angle (distal conditions: no-demonstration = 503 504 2, pull-cord = 2, lift-platform = 1, and proximal conditions: lift-platform = 1). A logistic regression analysis was conducted to evaluate whether success could be predicted by 505 presence of demonstration, reward location, and participant age. A test of the full model 506 against a constant only model was statistically significant ( $R^2 = .49$ ,  $X^2 = 72.3$ , p < .001; 507 supplementary material Table A). Greater success was predicted by presence of a 508 509 demonstration (p < .001), a proximal reward (p < .001), and increased age (p < .01). 510 Differences in latency to success were investigated, with unsuccessful children given a latency of 180s (three minutes). A stepwise multiple linear regression was conducted to 511 evaluate whether reward location, demonstration (present or absent), and participant age 512 were necessary to predict latency to success (supplementary material Table B). The model 513 514 accounting for the most variance (39%) included all three variables. Shorter latency to success was predicted by presence of a demonstration (p < .001), a proximal reward (p < .001) 515 .001), and increased age (p < .001). 516 517 Effects of reward contiguity on matching of demonstrated means 518 Of the 109/120 children that were successful following a demonstration, 98 (90%) of 519 520 them copied the demonstrated means. A logistic regression analysis was conducted to 521 evaluate whether copying of the demonstrated means could be predicted by reward location

522 and participant age. For a complete analysis, this was run twice, with unsuccessful children

523 either included (coded as having not copied the model) or excluded. When unsuccessful

524 children were included, the model that accounted for significantly more variance than no

predictors included both reward location (B = 2.16, SE B = 0.67, Exp(B) = 8.70, p < .01) and age (B = 0.06, SE B = 0.03, Exp(B) = 1.07, p < .05, R<sup>2</sup> = .26, X<sup>2</sup> = 20.56, p < .001). When unsuccessful children were excluded, the only model accounting for significantly more variance than no predictors included only reward location (B = 1.86, SE B = 0.81, Exp(B) = 6.42, p < .05, R<sup>2</sup> = .15, X<sup>2</sup> = 8.26, p < .05).

530

#### 531 Additional analyses of behavioral details

The majority (79.5%) of the 166 of children who interacted with the task (excluding 532 two participants where first touch was unclear) touched the means congruent location. A 533 534 logistic regression analysis was conducted to evaluate whether means congruent first touch could be predicted by three factors: demonstration presence, reward location and participant 535 age. A model excluding age, against a constant-only model, was statistically significant ( $R^2$ ) 536 =.28,  $X^2 = 33.21$ , p < .001; supplementary material Table A). Means congruent first touch 537 was predicted by presence of a demonstration (p < .001) and a proximal reward (p < .001). 538 Participants were allowed up to five trials in three minutes and 129 children completed all 539 five trials. The vast majority (95.4%) only used one means throughout all trials. 540

541

#### 542 Comparison between children and capuchins

Capuchins were significantly less likely to touch the means versus non-means side of the task than children (FET p < .001) and significantly more likely to touch the side of the task where the reward was located than children (FET p < .001, see Figure 3). For both species demonstration attention and success was affected by reward location (see Figure 4). Irrespective of reward location, children were significantly more likely to copy the method demonstrated than capuchins (FET p < .001).





551
552 *Figure 3: Location of first touches relative to task and food for children and capuchins*

553 *across all conditions*.





556 Figure 4: Summary of behavioral responses for individuals that witnessed a social

*demonstration. Two/three/four refer to ages of children in years* 

558

## Discussion

559	The current study explicitly manipulated reward location, relative to the means of
560	obtaining the reward, to test the hypothesis that spatial contiguity between a reward and the
561	means of accessing that reward affects social learning. We found evidence that, in two very
562	different species of primate, reward location had a significant impact upon visual attention
563	towards demonstrations of means and task success. Reward location also affected copying of
564	the demonstrated means although this effect was shaped by species and age. In the following
565	sections we discuss these results and their implications for our understanding of the
566	importance of spatial contiguity in social learning, for behavioral convergences and
567	divergences between children and capuchins, and developmental changes in children.
568	
569	Convergent behavioral patterns
570	For both species, the location of the reward had a significant effect on individual's
571	attention towards the task during social demonstration of the means. If the reward was
572	located proximal to the means, the majority of participants attended to this direction during
573	demonstration. Conversely, when the reward was located at the distal location to the means,
574	there was reduced attention towards the demonstrations and increased attention towards the
575	distal reward. We take this as the first evidence that the sight of a reward stimulus proves to
576	be an overpowering and distracting stimulus during social demonstrations. The distal reward
577	location reduced attention towards social information which likely impaired social learning.
578	For both species the location of the reward had a significant effect on levels of
579	success. When the reward was proximal to the means the majority of individuals were
580	successful whereas fewer individuals were successful when the reward was distal to the
581	means, although this difference was only significant for the children. The detrimental effect
582	of a distal reward to means location was evident in the increased latency to success for both

583 species. The relationship between measures of success and social learning are unclear because reward and means spatial contiguity was consistent in both the demonstration and 584 test phases. Consequently, the location of reward during the test phase, rather than during 585 586 demonstration, could have driven such an effect. Indeed, that: (a) two capuchins with no social information solved the task quickly; (b) previously successful capuchins in the 587 588 proximal condition often became slower when the reward moved to a distal location; and (c) reward location affected success for no-demonstration children, all suggest that reward 589 location may be sufficient for influencing success. Thus, the current study supports results 590 showing that spatial contiguity affects non-social associative learning in animals (Kushnir & 591 592 Gopnik, 2007; Polidora & Fletcher, 1964; Wasserman & Miller, 1997). However, differing success levels between children in the demonstration and no-demonstration conditions 593 indicated that the reward location during demonstration did affect their success. To further 594 assess the impact of reward location upon social learning we investigated copying of the 595 specific demonstrated means, which we address in the next section. 596

597

#### 598 **Divergent behavioral patterns**

Comparative studies of humans with other species can be problematic as divergent 599 600 behaviour may be due to the different methods used (Boesch, 2007) although, as Tomasello 601 & Call (2008) argue, methodological differences sometimes represent functional equivalence more so than exact matching. We acknowledge both sides of this debate and avoided an 602 603 explicit comparison of the two species. Hence, the species took part in two different 604 experiments and statistical comparisons were largely within each species. However, we feel it is appropriate to comment upon some of the behavioral divergences preceded by an outline 605 606 of the primary methodological differences concerning: the reward; the species (mis)matching 607 of the demonstrator; the presence of a primary caregiver; and the response time.

608 First, the reward differed as we wanted a high value reward for both species. Food preference tests indicated that a peanut was the highest value reward for the capuchins. We 609 were not able to offer a peanut to the children due to potential allergies. Thus, a sticker was 610 611 deemed an equivalent high value reward. However, s sticker did not reliably exit the apparatus so a gold plastic token was used. Second, the experimenter (demonstrator) for 612 613 every experiment was a human; thus the children had an unknown conspecific demonstrator 614 whereas the capuchins had a familiar non-conspecific demonstrator. A human was required to ensure appropriate demonstration control. Third, presence of a primary caregiver and 615 fourth, maximum response time differences were a product of aiming for equivalence in 616 617 terms of comfort. These capuchins are used to isolating and participating in experiments for 618 up to 15 minutes and those capuchins that were unsuccessful continued to interact with the task for the full five minutes. Conversely, the children were not used to isolating and 619 participating in experiments and we did not want to cause undue stress with extended 620 response times. We found, as with previous work (e.g., Wood et al., 2013), that three 621 minutes allowed sufficient time for testing, and children that were unsuccessful often ceased 622 interacting with the task in under two minutes. 623

A significant behavioral divergence was in the copying of the demonstrated means. 624 625 Children generally copied the specific means demonstrated although a distal reward location 626 significantly reduced rates of copying. We take this as the first evidence that reward and means proximity during demonstrations affects social learning in young children. The 627 evidence of such an effect with capuchins was far less clear. Capuchins in the proximal 628 condition showed a means choice that was significantly different to chance whereas those in 629 the distal condition did not. However, surprisingly and puzzlingly, the means choice of eight 630 of the nine capuchins in the proximal condition was *opposite* to the means demonstrated. We 631 tentatively suggest that capuchins in the proximal condition were attending to the means, but 632

633 counter to our intentions, the demonstrator's actions made the alternative means more salient. In reviewing videos, we noted that that in the pull-cord demonstration the 634 demonstrator's hand partially masked the grasped knobble, whereas the platform rising and 635 636 the entrance hole used for lift-platform remain clearly visible. Conversely, during the liftplatform demonstration the demonstrator's hand potentially masked the entrance hole of this 637 638 method whereas the alternative means remained clearly visible. Therefore, the means opposite to the one demonstrated may have been inadvertently more salient to the capuchins. 639 A difference in species relevance for the two species may have affected the salience of the 640 social demonstration (Boesch, 2007). Human hands may mean fundamentally different 641 things to a capuchin versus a human child, potentially explaining why the reversal effect 642 643 occurred with the capuchins but not the children. Thus, the capuchins may have been replicating these movements of components of the box (object movement centered) rather 644 than the actions of the demonstrator (model movement centered, Whiten et al., 2004). 645 A second behavioral divergence was that all but one of the capuchins' first touches 646 corresponded to the location of the reward whereas children's first touches were far more 647 likely to correspond to the location of the means. The difference in reward may have caused 648 this species difference; the food may have been far more salient for the capuchins and 649 650 appealing than the secondary reinforcer token for the children. However, previous research 651 indicates that children are very motivated to obtain a token that leads to the primary reinforcer of a sticker (e.g., Wood et al., 2012). Although a secondary reinforcer may be less 652

appealing and thus affect attention and prepotent responses to reach for it, we did not see any

evidence that children were less interested in attending to the apparatus or demonstrations.

655 We believe that the current study is a case where the reward was different but the functional

equivalence of the reward was equally salient (Tomasello & Call, 2008). Another

explanation of this first-touch divergence is that capuchins had less understanding of the task

658 material than the children and tried to access the reward through the transparent plastic. However, these capuchins have vast experience of transparent plastic in their enclosure, their 659 frequently used enrichment devices, and in previous apparatus. Alternatively, capuchins have 660 661 less inhibitory control and so reacted to a prepotent response to reach for food, as is species typical of capuchins (Amici et al., 2008; Beran et al., 2016). The current study cannot 662 663 confidently distinguish between these explanations but they are ripe for further exploration. The third notable species difference relates to solution conservatism. Although the 664 majority of the capuchins used both means, children generally showed high levels of 665 conservatism towards one means. Solution conservatism versus flexibility has been 666 667 investigated in several other primate species (e.g., chimpanzees: Hopper, Schapiro, Lambeth, 668 & Brosnan, 2011; vervet monkeys: van de Waal, Borgeaud, & Whiten (2013); and squirrel monkeys: Cladiere et al., 2013) and the current study shows that brown capuchin monkeys 669 are able to flexibly switch between different means. Conversely, only six children used 670 multiple methods in line with other research demonstrating high method conservatism in 671 672 children following social demonstrations (Hopper et al., 2010). However, the level of conservatism in the no-demonstration conditions is surprising given that previous work with 673 five-year-olds has shown that personal exploration may encourage multiple-method adoption 674 675 (Wood, Flynn, & Kendal, 2013). An age difference may explain these differences. The 676 results suggest that social information was not the reason for means conservatism in the 677 current study and therefore cannot explain why children were markedly more conservative than capuchins. 678

679

#### 680 Developmental changes

681 The age of a child was a significant predictor of: attention towards means and non-682 means sides of the task; success; and copying of the demonstrated means (when including

683 unsuccessful children). Although four-year-olds were somewhat distracted by the reward during the demonstration phase they were still able to attend to social information 684 sufficiently to be successful relatively quickly and to copy the demonstrated means. 685 Conversely, younger children were distracted by the reward, were less successful, and 686 showed less reproduction of the demonstrated means. Previous demonstrations by a human 687 688 conspecific using a transparent apparatus have not shown many development differences in the copying of the means between ages two- to five-years-old (Flynn, 2008; Flynn & 689 Whiten, 2008a & 2008b; Horner & Whiten, 2005; McGuigan et al., 2007; McGuigan & 690 Whiten, 2009). However, several of these studies that used the same apparatuses have 691 692 revealed developmental differences in some behavioral responses. For example, McGuigan et al. (2007) found that three-year-olds were less likely to copy the demonstrated means than 693 five-year-olds when the demonstration was via a video. The authors argue that for the 694 younger children "the degraded information led to a differential focus on the task outcome, 695 696 as opposed to the actions of the model, resulting in an emulative approach." (p. 362). The current study suggests that differences in the presentation of the means, as with the 697 capuchins, can affect younger children's attention more than older children's. This in turn 698 699 leads older children to copy the form of an action (model movement centred), and younger 700 children to copy the form of a caused object movement (object movement centred). 701 Likewise, McGuigan & Whiten (2009) compared their results with two- and threeyear-olds with that of McGuigan et al.'s (2007) study and found that in relation to copying of 702 703 causally irrelevant tool insertions within the means, age increase corresponded to an increase 704 in copying unnecessary demonstrated tool insertions and insertion method. This difference 705 was greatest when the reward was in an opaque chute held in a transparent versus opaque

apparatus. The authors suggest that the younger children may have "focused their attention

differently from the older children, with the 3- and 5-year-olds focusing their attention on the

708 actions of the model and the majority of the younger children focusing either on the results 709 of the task or on reproducing the movements of parts of the box" (p. 379). We suggest that, irrespective of box transparency, five-year-old children focus their attention on both the 710 actions of the model and the movement of parts affected. Conversely, and particularly when 711 an apparatus is transparent and the reward's location is salient, younger children are 712 distracted by the reward and so attend less to the model's actions. We speculate that this may 713 be a likely explanation for the developmental change towards inefficient copying, rather than 714 any developmental changes relating to strategies concerning what to copy. 715

A similar explanation could apply to an increase in chimpanzee's copying of causally 716 717 irrelevant tool insertions when the apparatus involved was opaque rather than transparent 718 (Horner & Whiten, 2005). Chimpanzees presented with the transparent apparatus may have been distracted by the reward location and thus primarily attended to demonstrated actions in 719 720 the area proximal to the reward, which they copied, while ignoring demonstrated actions distal to the reward which they failed to copy. We believe further investigation of this area is 721 important in our understanding of the phenomena of inefficient copying thus far documented 722 in older children and adults but not in younger children and other species. 723

724

725 Implications for social learning research

The current study has been the first to demonstrate significant effects of reward location on attention towards, and social learning from, demonstrations by others. It has highlighted how a small change in experimental and apparatus design can have a marked impact on behavioral responses associated with social learning. As noted in our introduction, capuchin social learning has appeared most evident and sophisticated when a single reward was protected by an opaque defense and where the action upon that defense was proximal to the reward. The results from the current study offer an explanation of why this might occur.

Apparent differences in evidence for social learning in multiple experiments with capuchins may instead reflect differences in spatial contiguity between reward and means. The same may also be true of apparent species differences where different apparatuses have been used. We would urge future work with all species to consider that seemingly minor changes in apparatus design can have a marked impact and that tasks which are opaque –the common occurrence in the wild - may offer the greatest chance of demonstrating an animal's social learning abilities.

The current study may aid an understanding of social learning differences between 740 species and across development insofar as demonstrating that capuchins and two-year-old 741 742 children are more easily distracted away from social information by a reward than four-year-743 old children. We are not claiming this is the only explanation for species and developmental differences in social learning, but such effects contribute to a greater understanding of social 744 745 learning and the distinctiveness of humans' social learning abilities. From as young as fouryears-old, children are able to attend to socially demonstrated solutions and reproduce these 746 solutions with high fidelity (here and McGuigan et al., 2007). Such high fidelity transmission 747 of behavioral traits between individuals has been proposed to be of key importance to the 748 749 evolution of cumulative culture (Boyd & Richerson, 1996; Tomasello, 1999). Research that 750 cannot only describe but explain differences in copying behaviors may help to unlock the 751 key to mankind's success.

#### 752 **References**

- Anderson, D. R., & Levin, S. R. (1976). Young children's attention to" Sesame Street". *Child Development*, 47(3), 806-811.
- Amici, F., Aureli, F., & Call, J. (2008). Fission-fusion dynamics, behavioral flexibility, and
  inhibitory control in primates. *Current Biology*, *18*(18), 1415-1419.
- 757 Aplin, L. M., Farine, D. R., Morand-Ferron, J., Cockburn, A., Thornton, A., & Sheldon, B. C.
- (2015). Experimentally induced innovations lead to persistent culture via conformity
  in wild birds. *Nature*, *518*(7540), 538-541.
- 760 Beran, M. J., Perdue, B. M., Rossettie, M. S., James, B. T., Whitham, W., Walker, B., Futch,
- S. E., & Parrish, A. E. (2016). Self-control assessments of capuchin monkeys with the
  rotating tray task and accumulation task. *Behavioural Processes*, *129*, 68-79.
- Bandura, A., & Walters, R. H. (1977). *Social learning theory*. New York, NY: General
  Learning Press.
- Boyd, R., & Richerson, P. J. (1996). Why culture is common, but cultural evolution is rare.
   *Proceedings-British Academy*, 88, 77-94.
- Bramlett, J. L., Perdue, B. M., Evans, T. A., & Beran, M. J. (2012). Capuchin monkeys
  (*Cebus apella*) let lesser rewards pass them by to get better rewards. *Animal Cognition*, 15(5), 963-969.
- Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen-through 18-month-old infants
  differentially imitate intentional and accidental actions. *Infant Behavior and*
- 772 *Development*, 21(2), 315-330.
- 773 Claidière, N., Messer, E. J., Hoppitt, W., & Whiten, A. (2013). Diffusion dynamics of
- socially learned foraging techniques in squirrel monkeys. *Current Biology*, 23(13),
- 775 1251-1255.

- Crast, J., Hardy, J. M., & Fragaszy, D. (2010). Inducing traditions in captive capuchin
  monkeys (*Cebus apella*). *Animal Behaviour*, 80(6), 955-964.
- Custance, D., Whiten, A., & Fredman, T. (1999). Social learning of an artificial fruit task in
  capuchin monkeys. *Journal of Comparative Psychology*, *113*(1), 13.
- Dawson, B. V., & Foss, B. M. (1965). Observational learning in budgerigars. *Animal Behaviour*, *13*(4), 470-474.
- Dindo, M., Thierry, B., & Whiten, A. (2008). Social diffusion of novel foraging methods in
  brown capuchin monkeys (*Cebus apella*). *Proceedings of the Royal Society B: Biological Sciences*, 275(1631), 187-193.
- Dindo, M., Thierry, B., de Waal, F., & Whiten, A. (2010). Conditional copying fidelity in
  capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *124*(1), 29.
- 787 Evans, T. A., Beran, M. J., Chan, B., Klein, E. D., & Menzel, C. R. (2008). An efficient

788 computerized testing method for the capuchin monkey (*Cebus apella*): Adaptation of

- the LRC-CTS to a socially housed nonhuman primate species. *Behavior Research Methods*, 40(2), 590-596.
- Flynn, E. (2008). Investigating children as cultural magnets: do young children transmit
   redundant information along diffusion chains? *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 363(1509), 3541-3551.
- Flynn, E. & Smith, K. (2012) Investigating the mechanisms of cultural acquisition. *Social Psychology*, *43*(4), 185-195.
- **796** Flynn, E., & Whiten, A. (2008a). Imitation of hierarchical structure versus component details
- 797 of complex actions by 3-and 5-year-olds. *Journal of Experimental Child*
- **798** *Psychology*, *101*(4), 228-240.
- Flynn, E., & Whiten, A. (2008b). Cultural transmission of tool use in young children: A
  diffusion chain study. *Social Development*, *17*(3), 699-718.

Fragaszy, D. M., & Visalberghi, E. (1989). Social influences on the acquisition of tool-using
behaviors in tufted capuchin monkeys (*Cebus apella*). *Journal of Comparative*

803 *Psychology*, *103*(2), 159.

- Fragaszy, D. M., & Visalberghi, E, & Fedigan, L. M. (2004). *The complete capuchin: the biology of the genus Cebus*. Cambridge, UK: Cambridge University Press.
- Fredman, T., & Whiten, A. (2008). Observational learning from tool using models by
- human-reared and mother-reared capuchin monkeys (*Cebus apella*). Animal *Cognition*, 11(2), 295-309.
- Giraldeau, L. A., & Lefebvre, L. (1987). Scrounging prevents cultural transmission of foodfinding behaviour in pigeons. *Animal Behaviour*, *35*(2), 387-394.
- Heyes, C. M. (1994). Social learning in animals: categories and mechanisms. *Biological Reviews*, 69(2), 207-231.
- 813 Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in
- 814 chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal cognition*, 8(3),
  815 164-181.
- Horner, V., Whiten, A., Flynn, E., & de Waal, F. B. (2006). Faithful replication of foraging
  techniques along cultural transmission chains by chimpanzees and
- 818 children. *Proceedings of the National Academy of Sciences*, *103*(37), 13878-13883.
- Hopper, L. M., Flynn, E. G., Wood, L. A., & Whiten, A. (2010). Observational learning of
- tool use in children: Investigating cultural spread through diffusion chains and
- 821 learning mechanisms through ghost displays. *Journal of Experimental Child*
- 822 *Psychology*, *106*(1), 82-97.
- 823 Hopper, L. M., Lambeth, S. P., Schapiro, S. J., & Whiten, A. (2008). Observational learning
- 824 in chimpanzees and children studied through 'ghost' conditions. *Proceedings of the*
- 825 *Royal Society of London B: Biological Sciences*, 275(1636), 835-840.

- 826 Hopper, L. M., Schapiro, S. J., Lambeth, S. P., & Brosnan, S. F. (2011). Chimpanzees'
- socially maintained food preferences indicate both conservatism and conformity. *Animal Behaviour*, *81*(6), 1195–1202.
- 829 Kochanska, G., Murray, K., Jacques, T. Y., Koenig, A. L., & Vandegeest, K. A. (1996).
- 830 Inhibitory control in young children and its role in emerging internalization. *Child*831 *Development*, 490-507.
- Kushnir, T., & Gopnik, A. (2007). Conditional probability versus spatial contiguity in causal
  learning: Preschoolers use new contingency evidence to overcome prior spatial
  assumptions. *Developmental Psychology*, *43*(1), 186.
- 835 Leonardi, R., Buchanan-Smith, H. M., Dufour, V., MacDonald, C., & Whiten, A. (2010).
- 836 Living together: behavior and welfare in single and mixed species groups of capuchin
- 837 (*Cebus apella*) and squirrel monkeys (*Saimiri sciureus*). American Journal of
- 838 *Primatology*, 72(1), 33-47.
- 839 Macdonald, C., & Whiten, A. (2011). The 'Living Links to Human Evolution' Research
- 840 Centre in Edinburgh Zoo: a new endeavour in collaboration. *International Zoo*841 *Yearbook*, 45(1), 7-17.
- McGuigan, N., Whiten, A., Flynn, E., & Horner, V. (2007). Imitation of causally opaque
  versus causally transparent tool use by 3-and 5-year-old children. *Cognitive*
- 844 *Development*, 22(3), 353-364.
- 845 McGuigan, N., & Whiten, A. (2009). Emulation and "overemulation" in the social learning of
- causally opaque versus causally transparent tool use by 23-and 30-month-
- 847 olds. Journal of Experimental Child Psychology, 104(4), 367-381.
- 848 Perry, S. (2011). Social traditions and social learning in capuchin monkeys
- 849 (Cebus). Philosophical Transactions of the Royal Society B: Biological
- 850 *Sciences*, *366*(1567), 988-996.

- 851 Perry, S., Baker, M., Fedigan, L., Gros-Louis, J., Jack, K., MacKinnon, K. C., ... & Rose, L.
- 852 (2003). Social conventions in wild white-faced capuchin monkeys. *Current*853 *Anthropology*, 44(2), 241-268.
- Polidora, V. J., & Fletcher, H. (1964). An analysis of the importance of SR spatial
- 855 continguity for proficient primate discrimination performance. *Journal of*
- 856 *Comparative and Physiological Psychology*, 57(2), 224.
- Ruff, H. A., & Capozzoli, M. C. (2003). Development of attention and distractibility in the
  first 4 years of life. *Developmental Psychology*, *39*(5), 877.
- 859 Thornton, A., & Malapert, A. (2009). Experimental evidence for social transmission of food
  860 acquisition techniques in wild meerkats. *Animal Behaviour*, 78(2), 255-264.
- Tomasello, M. (1996). Do apes ape? In C. M. Heyes & B. G. Galef (Eds), *Social learning in animals: The roots of culture* (pp. 319-346), London, UK: Academic Press.
- 863 Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA:Harvard
  864 University Press.
- Whiten, A., & Ham, R. (1992). Reappraisal of a century of research. *Advances in the Study of Behavior*, *21*, 239.
- Whiten, A., Horner, V., Litchfield, C. A., & Marshall-Pescini, S. (2004). How do apes
  ape? *Animal Learning & Behavior*, 32(1), 36-52.
- Whiten, A., Horner, V., & De Waal, F. B. (2005). Conformity to cultural norms of tool use in
  chimpanzees. *Nature*, 437(7059), 737-740.
- van de Waal, E., Borgeaud, C., & Whiten, A. (2013). Potent social learning and conformity
  shape a wild primate's foraging decisions. *Science*, *340*(6131), 483-485.
- van de Waal, E., Renevey, N., Favre, C. M., & Bshary, R. (2010). Selective attention to
- 874 philopatric models causes directed social learning in wild vervet monkeys.

- 875 Proceedings of the Royal Society of London B: Biological Sciences, 277(1691), 2105-
- 876 2111.
- 877 Visalberghi, E. (1993). Capuchin monkeys: A window into tool use in apes and humans. In
- 878 K. Gibson & T. Ingold (Eds.), *Tools, language, and cognition in human evolution* (pp.
- 879 138-150). Cambridge, UK: Cambridge University Press.
- Wasserman, E. A., & Miller, R. R. (1997). What's elementary about associative learning? *Annual Review of Psychology*, 48(1), 573-607.
- Wood, L. A., Harrison, R. A., Lucas, A. J., McGuigan, N., Burdett, E. R., & Whiten, A.
- 883 (2016). "Model age-based" and "copy when uncertain" biases in children's social
- learning of a novel task. *Journal of Experimental Child Psychology*, 150, 272-284.
- 885 Wood, L. A., Kendal, R. L., & Flynn, E. G. (2013). Whom do children copy? Model-based
- biases in social learning. *Developmental Review*, *33*(4), 341-356.

- 887
- 888

#### **Supplementary Material**

- 889 Table A; Summary of binomial logistic regression analysis for variables predicting success
- and location of first touch (children).

	Success			Means cong	gruent first tou	ıch
Variables	В	SE B	Exp(B)	В	SE B	Exp(B)
Demonstration by model	3.20	0.52	24.49***	-1.81	0.44	0.16***
Reward Location	1.84	0.50	6.28***	-1.71	0.49	0.18***
Age in months	0.07	0.02	1.07**	-0.01	0.02	0.99
Nagelkerke's R <sup>2</sup>			.49			.28
$X^2$			72.3***			33.21***

891 p < .05. \*\*p < .01. \*\*\*p < .001. Means congruent first touch no= 0, yes= 1. Demonstration

892 by model; no=0, yes=1. Reward location; proximal = 1, distal = 0

- 893
- 894

895 Table B; Summary of multiple linear regression analysis for variables predicting latency to

success.

	Success		897
Variables	В	SE B	Beta <sup>898</sup>
Demonstration by model	-82.54	9.32	-0.52* <sup>\$99</sup>
Reward Location	-37.68	8.79	-0.25*900
Age in months	-1.70	0.43	-0.23*901
<b>R</b> <sup>2</sup>			.39 902
F			37.28* <sup>903</sup>
			904

905 \*\*\*p < .001. Demonstration by model; no = 0, yes = 1. Reward location; proximal = 1, distal

**906** = *0*.