Over-Imitation in the Kalahari Desert and the Origins of Human Cultural Cognition

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Children grow up in environments saturated with tools and objects which they must learn to use. One of the most efficient ways in which children do this is by imitating. Recent work has shown that, in contrast to non-human primates, when young children learn by imitating they focus more on reproducing the specific actions used than the actual outcomes achieved.From about 18 months of age children will routinely copy arbitrary and unnecessary actions. This puzzling behaviour is called 'over-imitation'. By documenting similarities exhibited bychildren from a large, industrialised city and children from remote Bushman communities in southern Africa,we provide here the first indication that over-imitation is a universal human trait. We also show that over-imitation isunaffected by the age of the child, testing environment, or familiarity of the demonstrating adult. Furthermore we argue that, although seemingly maladaptive, over-imitation reflects an evolutionary adaptation fundamental to the development and transmission of human culture.

Research has recorded young children's propensity for learning how to use objects by copying others – a propensity that stands them apart from other animals[12]. That children have been shown to be strong imitators in this way makes intuitive sense. Directly replicating others affords the rapid acquisition of novel behaviors while at the same timeavoiding the potential pitfalls and false end-points that can come from trial-and-error learning. Recentresearch however, has revealed that young children will copy the explicit actions of an adult demonstrator even when a more efficient method is available and even if copying the adult's actions results in failure to bring about the demonstrated outcome[345]. For example, children aged 3 to 5 years were trained to identify the causally irrelevant parts of novel action sequences performed byanadult on familiar household objects (such as retrieving a toy from a plastic jar after first stroking the side of the jar with a feather)[6].The children then watched as the adult demonstrated a sequence of actionson novel objects whereby the causalsignificance of the actions was directly observable.Despite the training, children still reproduced causally irrelevant actionsand they continued to do so even when specifically instructed by the adult to only copy necessary actions.

Over-imitationemergesin the second year and becomes increasingly pervasive through the pre-school period[57].Why children engage in this high fidelity copying is a topic of increasing debate[689]. Yet interpretations of over-imitation, and assumptions regarding its meaningfulness, are constrained by limiting documentation to children living in relatively affluent, urban, Westernised cultures. There are reasons to suspect that over-imitation might not occur in other environments.

In most Western cultures typical parent-child interaction is characterised by parents frequently demonstrating objects for their children and highlighting their critical features[1011]. Children are commonly shown what things are and how to use them via ordered, guided instruction. Children can thusassume that adults have tested the rationality of their novel actions and hence that these actions are attempts to transmit relevant knowledge[912].This is fertile ground for over-imitation to flourish. But instruction of this kind does not happen in all cultures. In many indigenous communities, and certainly among hunter-gatherers, there is minimal adult tuition related to object manipulation. Children are mostly expected to learn through observation, and caregivers rarely explore object use with their children[1314]. If over-imitation emerges fromthe pedagogical approach adopted by parents inWesternised cultures, children living in more traditional environments should be less likely to engage in it. We thus hypothesised that child descendents of hunter-gatherers would over-imitate at reduced rates when compared with children from a Western background.

To test this hypothesis, in Experiment 1 we studiedyoungchildren (2-6yrs.)from two Bushman communities in remote regions of the Kalahari Desert(Witdraai, South Africa and Ngwatle, Botswana – see Fig. 1), and children of the same age range fromBrisbane, a large urban city in Australia. The Bushman children are recent ancestors of true hunter-gatherers living in communities where many aspects of traditional culture are maintained[15].By contrast, the Brisbane children are typical of those living inlarge, Westernised, industrialised cities. The Brisbane children were tested sitting at a desk in a

quiet room of their day-care centre. The Kalahari children were tested outside, sitting on the ground near their homes.

Insert Figure 1 about here[16]

Children participated in one of two conditions. In a *Demonstration Condition*children watched an adult use a miscellaneous object (e.g., a blue stick) first in a causally irrelevant way (e.g., wiping it across the top of a novel box) and then in a causally connected manner (e.g., to open the box by poking out dowels that secured its lid shut – see Fig. 2). Following demonstration the box andobject were given to the child. This procedure was repeated for two more boxes, each with different action-object pairings (see Supplementary Material for full details). To assess spontaneous production of the target actions children in a *No Demonstration* condition were given the boxes and associated objectsone by one, but did not see any actions demonstrated.

There were two dependent variables for each box: (1) reproducing the irrelevant action; and (2) using the object to open the box. For each box, children were awarded 1 point for performing the target action and 0 for failing to do so. Summed across boxes, children could thus score between 0 and 3 for each variable.

Insert Figure2 about here

Most of the children in the Demonstration conditionsubsequently produced the irrelevant actions on all three boxes,unlike the children in the No

Demonstration condition ($mean_{Demonstration}$=2.69 boxes, $mean_{No\ Demonstration}$=0.13 boxes, independent samples *t*-test, t(30) = 14.81, two-tailed *P*<0.001) (Fig. 3). They were also more likely to openthe boxes using the object ($mean_{Demonstration}$=2.19, $mean_{No\ Demonstration}$=0.25, independent samples *t*-test, t(30) = 6.20, two-tailed *P*<0.001). Critically, and contrary to our hypothesis, children in the Demonstration condition produced the irrelevant actions at similar rates regardless of their cultural environment ($mean_{Brisbane\ Children}$=2.87, $mean_{KalahariChildren}$=2.50, independent samples *t*-test, t(14) = 1.27, two-tailed *P*=0.224). They also used the object to open the boxes at similar rates ($mean_{Brisbane\ Children}$=2.25, $mean_{KalahariChildren}$=2.12, independent samples *t*-test, t(14) = 0.22, two-tailed *P* = 0.830).

Insert Figure 3 about here

Childrenin the Demonstration condition consistently copied the irrelevant actions and object use techniques to which they were exposed. Children who did not see the actions demonstrated rarely produced them. Thus, children in the Demonstration condition were not exhibiting the target actions because they represent pre-potent responses or because they are the most obvious means of bringing about the desired outcome. Rather, their behaviour is consistent with experimental studies whichshow children'svehement attraction to replicate with high fidelity the object-directed behaviours of others. This pervasive behaviour is attested to by the similarity of responses, irrespective of cultural background. Furthermore high-fidelity imitation provesunrestricted by the nature of the experimental setting or a specific socio-economic context.

One suggestion why young children imitate seemingly irrelevant actions is that they lack the cognitive sophistication necessary to appreciate how specific actions are causally related to the outcomes of those actions [71718]. To investigate this possibility, in Experiment 2 we tested over-imitation in a new group of Bushman children aged from 2 to 13 years. If over-imitation is a function of young children's immaturity in discerning the causal efficacy of a model's actions, older children should be less likely to reproduce irrelevant actions. As with Experiment 1, children were split into Demonstration and No Demonstration groups. After they had been given opportunity to explore the apparatus, children in the No Demonstration condition now watched the model demonstrate the target actions. If over-imitation emerges from children's failure to comprehend the causal relations between actions and their consequent outcomes children in the No Demonstration condition who discover how to operate the apparatus on their own should be disinclined to copy the irrelevant actions subsequently shown to them by the model.

The participantswere !Xun andKhwe children living in Platfontein, an immigrant Bushman settlement on the outskirts of Kimberley, in South Africa's Northern Cape.These groups were relocated to South Africa from Angola and Namibia after the end of the border war in which they had sided with the South African Defence Force which had employed them as trackers[19]. The children had grown up in a tented camp, Schmidsdrift, in the Northern Cape countryside, before being housed in the sub-economic settlement in Platfontein[19].

A single demonstrator conducted all testing in Experiment 1. To ensure that the responses of the children were not attributable to something

inadvertently associated with demonstrator characteristics, in Experiment 2 three members of the local community and three visiting experimenters acted as demonstrators. All testing was conducted in a small room of a community centre and children were tested individually while sitting at a desk opposite the model. Children were randomly assigned to one of two conditions – *Demonstration* and *No-demonstration* + *Demonstration*. The *Demonstration* condition was identical to Experiment 1. The No-demonstration + Demonstration condition was split into two phases. As per the No-demonstration condition of Experiment 1, children in thiscondition were first given the apparatus and associated objects one by one, without seeing any actions demonstrated(No-demonstration phase). After they had opportunity to explore all three apparatuses the children then watched the model demonstrate the target actions and were once more given the apparatus as per the Demonstration condition (Post-demonstration phase).

The type of demonstrator (stranger or local community member) had no impact on children's performance (see Supplementary Results). This is not considered further. Replicating the results of Experiment 1 (Fig. 2), children in the Demonstration groupproduced the irrelevant actions significantly more than children in the no-demonstrationphase of the No-demonstration + Demonstration condition ($mean_{Demonstration}$=2.79, $mean_{No\text{-}demonstration}$=0.14, independent samples *t*-test, t(60) = 19.53, two-tailed *P*<0.001) and they opened more boxes ($mean_{Demonstration}$=2.59, $mean_{No\text{-}demonstration}$=0.00, independent samples *t*-test, t(60) = 17.46, two-tailed *P*<0.001).

The sample was split into younger (aged 2-5 years) and older (aged 6-13 years) children. In the Demonstration condition, younger children produced

fewer irrelevant actions than older children ($mean_{Younger}$=2.65, $mean_{Older}$=3.00, independent samples *t*-test, t(32) = 2.22, two-tailed *P* = 0.034), and opened fewer boxes ($mean_{Younger}$=2.35, $mean_{Older}$=2.93, independent samples *t*-test, t(32) = 2.25, two-tailed *P* = 0.032). There were no age-related differences for children in the No-demonstration + Demonstration condition (see Supplementary Results).

Children in the No-demonstration + Demonstration condition did not produce the irrelevant actions spontaneously but did so after seeing the model enact them ($mean_{No\text{-}demonstration}$=0.14, $mean_{Post\text{-}demonstration}$=2.75, paired samples *t*-test, t(27) = 15.76, two-tailed *P*<0.001). These children also did not spontaneously open the boxes by object but did so after watchingthe model($mean_{No\text{-}demonstration}$=0.00, $mean_{Post\text{-}demonstration}$=2.75, paired samples *t*-test, t(27) = 22.54, two-tailed *P*<0.001).Further, children copied the model's irrelevant actions at equivalent rates irrespective of whether or not they had prior opportunity to explore the boxes ($mean_{Demonstration}$=2.79, $mean_{Post\text{-}demonstration}$=2.75, paired samples *t*-test, t(60) =0.31, two-tailed *P*=0.759). Similarly, opportunity to explore the boxes did not impact children's tendency to copy the demonstrator's use of the objectto get the boxes open($mean_{Demonstration}$=2.59, $mean_{Post\text{-}demonstration}$=2.75, paired samples *t*-test, t(60) =0.88, two-tailed *P* =0.385). Moreover, 10 children in the No-demonstration phase discovered by trial-and-error how to open all three boxes by hand. Despite having identified on their own how to do this, in the Post-modelling phase each of these children subsequently reproduced both the model's irrelevant actions and object use on all three boxes.

A possible explanation for young children's propensity for over-imitation is that they lack the maturity to discern the causal relations between the model's actions and the outcome of those actions. Yet the older children we tested were more inclined than the younger children to copy the model. Also, children who were first given opportunity to discover the affordances of the test apparatus still reproduced the model's actions and did so at similar rates to children who were not given such opportunity. Even when children discovered on their own how to open all three apparatuses by hand, upon subsequent demonstration of a more complicated method incorporating irrelevant actions each of these children persisted in copying the adult. It isthus unlikely that children's high fidelity imitation is solely attributable to theircapacity for causal understanding.

No previous study has documented imitation across such starkly contrasting cultures and test environments. The similarity of performance is profound: children living in remote, impoverished Bushman communities, tested sitting on the ground, beneath a tree imitated in ways indistinct from children living in an industrialised, urban city tested inside, sitting at a desk. Their performance was similarly unaffected by age, cultural background of the model, or the children's opportunity to learn on their own how to operate the apparatus. The current study thus presentssignificant evidence of over-imitation as a universal human trait.

Furthermore, there is no evidence of over-imitation in any non-human animal[4]. For example, in their now seminal work, Horner and Whiten[3]documented how 3- to 4-year-old children will imitate an adult's entire sequence of actions, including those that are obviously irrelevant, whereas

chimpanzees will only replicate actions that are causally related to the desired outcome. Unlike children, chimpanzee copyingbehaviour appears to be driven by a prioritization of outcomes over actions.

This distinction between action and outcome is an important one. We have demonstrated here how young children are drawn towards copying the actions they see adults perform, so much so that children will persistently replicate the actions of an adult even if such actions interfere with production of the desired outcome[345]. Although at first glance such behaviour seems maladaptive,we view it as quintessential to the development and transmission of human culture. Consider the multitude of complex social activities humans engage in. We make tools together, court each other, develop political institutions, construct dwellings, and prepare meals. But precisely *how* we engage in these activities differs, often strikingly, from one community to another: Human behaviour varies profoundly across cultures, and this profound cultural variation is uniquely human[2021]. Critically, in understanding aspects of human behaviour that are culturally instantiated, it is knowing the *way* things are done that is important, not *what gets done*. Knowing that a group of people cook meat (an 'end') provides only limited information about their cultural heritage. Knowing *how* they prepared and cooked that meat (the 'means') tells you far more. When analysing cultural differences, means are more important than ends. And this focus on means over ends is precisely what is entailed in over-imitation. Over-imitation should not, therefore, be viewed as a quirk of the psychology laboratory but as providing a glimpse into the origins of our human propensity to follow those around us and to do as others do, irrespective of the logic underpinning such behaviour.

It is important to note that children do not blindly copy everything they see adults do. Characterised by some as selective imitators[222324], children will make judgements about what actions to copy based on a host of variables, including the apparent intentions of the model and the situational constraints confronting both model and child. Such characterisation adds spice to the growing debate as to why children over-imitate. Targeted research is now needed to provide a clearer picture of the circumstances that determine when children will do precisely as others have done and when they instead choose their own actions.

Other animals use tools and may have the rudiments of culture, but no animal uses tools or has developed culture with the breadth and complexity of our species.In over-imitation we see a mechanism for the rapid, high fidelity inter-generational transmission of tool-use skills andfor the perpetuation and generation of cultural forms.The study of this behaviour promises to provide critical insight into the development of these two core human traits.

METHODS SUMMARY

Subjects in Experiment 1 were 32 children aged between 2 and 6 years. The 16Brisbane children were recruited from a childcare centre adjacent to the university. The 16 Bushman children were tested at two sites, Witdraai(South Africa) and Ngwatle(Botswana). The Witdraai children were recruited through the South African San Institute (SASI) and the Ngwatlechildren through local community contacts. Sixty-two children aged between 2 and 13 years participated in Experiment 2. These children – members of the !Xun and Khwe communities - were living in Platfontein, a Bushman settlement on the outskirts of Kimberley, a country town in South Africa's Northern Cape. They were recruited via SASI. KT has been working with the Kalahari communities for over 15 years and is a trusted visitor.

Children participated in one of two conditions. In a *Demonstration Condition*children watched an adult touch a novel box with a miscellaneous object (e.g., a blue stick) in a

causally irrelevant way (e.g., wiping it across the top of the box). The object was then used in a causally connected manner to open the box (e.g., by poking out dowels that secured the lid of the box shut). When the box was opened a hidden toy was revealed. The demonstration was repeated twice more. Following the third demonstration the box and object were given to the child who was given 60 seconds to play with the items. This procedure was repeated for two more apparatus, each with different action-object pairings (see Supplementary Material for full details). Children in a *No Demonstration* condition were given the boxes and associated objects one by one, but did not see any actions demonstrated. In Experiment 2, children assigned to the No-Demonstration condition were subsequently shown the target actions after their unguided exploration of the apparatus.

Full Methodsand any associated references are available in the online version of the paper at www.nature.com/nature.

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Figure Legends

Figure 1. Southern Africa test locations for Experiment 1 (Witdraai and Ngwatle) and Experiment 2 (Kimberly), Map adapted from Willet et al.[16]

*Figure 2.*Causally relevant action for one box being demonstrated in the Kalahari.

Figure 3. Mean number (and standard error) of boxes on which children produced the irrelevant actions and opened by object across conditions in Experiment 1 (Demonstration and No Demonstration) and Experiment 2 (Demonstration, No demonstration Phase and Post-Demonstration Phase).

Figure 1

Figure 2

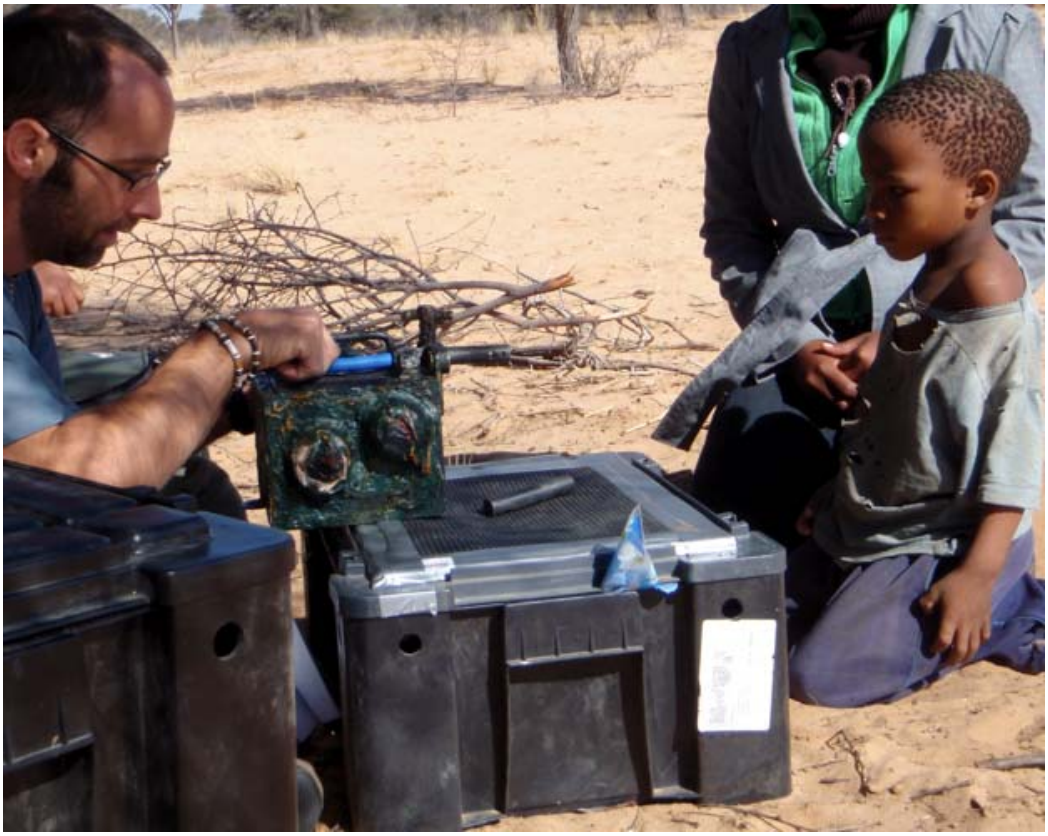

Figure 3