Cognition 142 (2015) 322–332

Contents lists available at ScienceDirect

Cognition

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

Imitate or innovate? Children's innovation is influenced by the efficacy of observed behaviour

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ARTICLE INFO

Article history:
Received 23 December 2014
Revised 5 May 2015
Accepted 6 May 2015
Available online 11 June 2015

Keywords:
Innovation
Behaviour efficacy
Imitation
Selective social learning
Asocial learning
Trade-offs

ABSTRACT

This study investigated the age at which children judge it futile to imitate unreliable information, in the form of a visibly ineffective demonstrated solution, and deviate to produce novel solutions ('innovations'). Children aged 4–9 years were presented with a novel puzzle box, the Multiple-Methods Box (MMB), which offered multiple innovation opportunities to extract a reward using different tools, access points and exits. 209 children were assigned to conditions in which eight social demonstrations of a reward retrieval method were provided; each condition differed incrementally in terms of the method's efficacy (0%, 25%, 75%, and 100% success at extracting the reward). An additional 47 children were assigned to a no-demonstration control condition. Innovative reward extractions from the MMB increased with decreasing efficacy of the demonstrated method. However, imitation remained a widely used strategy irrespective of the efficacy of the method being reproduced (90% of children produced at least one imitative attempt, and imitated on an average of 4.9 out of 8 attempt trials). Children were more likely to innovate in relation to the tool than exit, even though the latter would have been more effective. Overall, innovation was rare: only 12.4% of children innovated by discovering at least one novel reward exit. Children's prioritisation of social information is consistent with theories of cultural evolution indicating imitation is a prepotent response following observation of behaviour, and that innovation is a rarity; so much so, that even maladaptive behaviour is copied.

1. Introduction

Social learning provides the foundation for culture. Acquiring information through observation is a rapid, cheap and largely efficient way to learn. Yet, on occasion, social information is outdated or inappropriate, especially in changing environments; thus its use must be modulated to support accurate and reliable information acquisition (Boyd & Richerson, 1985; Kameda & Nakanishi, 2002). Accordingly, personal sampling of the environment, even if costly, is a necessity (Laland, 2004). Theoretical models have suggested many learning heuristics (cultural transmission biases; Boyd & Richerson, 1985 and social learning strategies; Laland, 2004) which enable selectivity in social learning. These heuristics help direct whom, when and what we copy by inducing accuracy-cost evaluations of observed and personal information and, in turn, adaptive trade-offs in reliance on social and asocial (individual) learning (Kendal, Coolen, & Laland, 2009; Kendal, Coolen, van Bergen, & Laland, 2005).

Adaptive informational trade-offs have been shown in a variety of non-human animals (including species of fish, rats, monkeys and birds; see Galef & Laland, 2005; Kendal et al., 2009). By pitting social and personal information against one another, it appears that, 'animals use social information primarily as plan B, or a backup when personal information is too costly to obtain, unreliable or outdated' (Rieucau & Giraldeau, 2011, p. 950). In van Bergen, Coolen, and Laland (2004), three groups of nine-spined stickleback fish were provided with personal information that varied in its level of reliability (56%, 78% or 100% reliable). This information related to the profitability of food patches within the experimental tank, and was determined by the number of trials in which 'rich' and 'poor' feeders could be accessed. A social ('public') demonstration then provided conflicting information as to the location of the rich feeder. In spite of this demonstration, a significant number of sticklebacks within the 100% group (19 of 23) continued to visit the feeder they had personally experienced as rich,

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http://dx.doi.org/10.1016/j.cognition.2015.05.005
0010-0277/

thus negating the conflicting social information. As with van Bergen, Coolen, and Laland (2004), in the current study we manipulated information reliability with the aim of observing adaptive trade-offs in learning. However, given children's proclivity for imitation, and apparent tendency to collect social information despite possessing adequate personal information (Wood, Kendal, & Flynn, 2013a), we did so by manipulating the reliability of *social* information.

Children are exceptional imitators from a young age, reproducing behaviour with high levels of fidelity across contexts (Matheson, Moore, & Akhtar, 2013) and in the absence of causal knowledge of its relevancy (Lyons, Young, & Keil, 2007). Indeed, they are deemed 'cultural magnets' (Flynn, 2008) in their ability to both rapidly acquire and transmit information socially (Flynn & Whiten, 2008; Hopper, Flynn, Wood, & Whiten, 2010). However, children are not blind to the quality of information they observe. By altering the frequency and fidelity with which they imitate, in line with the perceived goal of a demonstration (Bekkering, Wohlschläger, & Gattis, 2000; Carpenter, Call, & Tomasello, 2005), model reliability and intentionality (Birch, Vauthier, & Bloom, 2008; Carpenter, Akhtar, & Tomasello, 1998), task difficulty and prior experience (Gardiner, Bjorklund, Greif, & Gray, 2012; Pinkham & Jaswal, 2011; Williamson & Meltzoff, 2011; Wood et al., 2013a), children display rationality and flexibility in their social learning (Koenig & Sabbagh, 2013; Mills, 2013; Over & Carpenter, 2012).

A variety of factors, including context, model characteristics and information content, affect the use of social information (Rendell et al., 2011; Wood, Kendal, & Flynn, 2013b); here, our focus is on the efficacy of the information content. Action efficacy should arguably be a foremost determinant of what (and if) we choose to copy. By 3 years of age children distinguish correct from incorrect actions in their imitative behaviour, only reproducing those that have a desired causal effect (Want & Harris, 2001). Further, prior personal difficulty with a task does not induce 3-year-olds to have a copy-all approach when non-efficacious acts are demonstrated (Williamson, Meltzoff, & Markman, 2008). If a causal relationship is unknown, faithful imitation may result. However, if action sequences are repeatedly poor at producing desired outcomes, their efficacy should be questioned and imitation less likely to occur. Thus, logically, in circumstances under which a sequence of behaviour is never or rarely effective at achieving a goal, individuals should try new methods.

Few studies have attempted to examine how evaluations of efficacy affect selective imitation, and subsequent novel action production (or *innovation*). Schulz, Hooppell, and Jenkins (2008) tested 18-month-olds and 4-year-olds in conditions that differed in an action's efficacy: deterministic, in which the actions activated the toy on all trials and stochastic, in which actions activated the toy on 50% of trials. Children of both age groups imitated with significantly lower fidelity in the stochastic condition than the deterministic condition, irrespective of whether the action satisfied the explicitly stated goal of the model. Thus, in the stochastic condition, efficacy overrides pedagogy. However, as Schulz et al. (2008) acknowledge, the potential for alternative responses on the task, and the opportunity to observe behavioural innovation, was limited.

In recent years, interest in childhood innovation has grown, and studies suggest that, in the tool-use domain, innovation is a relatively late-developing capacity (Beck, Apperly, Chappell, Guthrie, & Cutting, 2011; Hanus, Mendes, Tennie, & Call, 2011; Nielsen, 2013) and a rare response for children (Whiten & Flynn, 2010). Factors such as functional fixedness (German & Defeyter, 2000), explicit instruction (Bonawitz et al., 2011), prior social information (Wood et al., 2013a), and task structure (Cutting, Apperly, Chappell, & Beck, 2014) likely constrain it. Innovation can be delineated in terms of arising from asocial learning (innovation by independent invention) or a combination of asocial and social learning (innovation by modification; Carr, Kendal, & Flynn, under revision). Most research investigating children's innovation has examined novel tool invention as opposed to novel modification. Yet, examination of the latter is critical as it is of great importance for *cumulative* culture (Lewis & Laland, 2012), where, over generations, humans build upon and improve pre-existing knowledge (Dean, Kendal, Schapiro, Thierry, & Laland, 2012). Currently we do not know whether innovation by modification has the same late developmental trajectory as independent invention. The current study addresses this issue through the provision of social demonstrations to individual children, across the age range of 4–9 years, followed by multiple response trials, thus providing many opportunities for innovation as well as multiple tools with which to innovate.

We ask, when evaluating efficacy of observed actions, at which point do children judge it futile to imitate? Do we see different assessments of redundancy at different ages? And does varying action efficacy make children more likely to innovate (produce novel behaviour) when given sufficient opportunity and means to do so? Even if children do not know of a behavioural alternative, they should nevertheless explore novel actions (Schulz et al., 2008) – trading-off social information for potentially more reliable personal information.

Our study used a novel artificial fruit (Whiten, Custance, Gomez, Teixidor, & Bard, 1996), the Multiple-Methods Box (MMB), a puzzle box offering scope for exploration and innovation (we distinguish exploration and innovation here as they are regarded as qualitatively distinct (Reader & Laland, 2003): you may explore, but you may not always innovate). Drawing from van Bergen et al. (2004), children were provided with social demonstrations that differed in solution efficacy: the proportion of trials (0%, 25%, 75%, 100%) that a reward could be extracted from the exit door of the MMB. Multiple demonstration and attempt trials were provided to reduce the likelihood that the novel task and experimental context would incite a copy-when-uncertain bias (Laland, 2004) and to monitor if, and how, participants changed their reliance on social and/or personal information over trials (Flynn & Smith, 2012; Wood et al., 2013a). With increasing experience with the MMB, both through observation and personal use, participants could establish the demonstrated method's efficacy and, in the lower efficacy conditions, appreciate the redundancy of repeating a method that simply did not work.

Children aged 4–9 years were selected so as to capture developmental change and is in keeping with that of previous innovation research (Beck et al., 2011). Moreover, children are adept at assessing efficacy by 4 years (Want & Harris, 2001; Williamson et al., 2008) and able to differentiate information that is reliable 75% of the time from information that is reliable 25% of the time (Pasquini, Corriveau, Koenig, & Harris, 2007). We predicted, in line with Want and Harris (2001) and Schulz et al. (2008), that lower levels of solution efficacy would be associated with reduced imitation (lowered fidelity to the socially demonstrated method), and, further, increased innovation (specifically, innovations that altered the reward exit and thus allowed for extraction). Moreover, we anticipated that older children would be better equipped to both evaluate levels of solution efficacy (resulting in a stronger negative relationship between efficacy and innovation with increasing age) and reach effective innovative solutions (with the greatest rates of successful innovation being seen in the oldest age group). In turn, we predicted that, overall, the oldest children would be the least faithful to the socially demonstrated method. Finally, given the range of novel behaviours that could be produced with the MMB, we explore how participants deviated from the socially demonstrated method (if and when they did) with regard to whether they