PAPER

When does social learning become cultural learning?

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Abstract

Developmental research on selective social learning, or 'social learning strategies', is currently a rich source of information about when children copy behaviour, and who they prefer to copy. It also has the potential to tell us when and how human social learning becomes cultural learning; i.e. mediated by psychological mechanisms that are specialized, genetically or culturally, to promote cultural inheritance. However, this review article argues that, to realize its potential, research on the development of selective social learning needs more clearly to distinguish functional from mechanistic explanation; to achieve integration with research on attention and learning in adult humans and 'dumb' animals; and to recognize that psychological mechanisms can be specialized, not only by genetic evolution, but also by associative learning and cultural evolution.

Research highlights

- Research on the development of selective social learning becomes interesting when it identifies psychological mechanisms that are specialized for cultural inheritance.
- Specialized mechanisms would be easier to identify if research on selective social learning more clearly distinguished mechanistic from functional explanations, and was better integrated with other areas of cognitive science.
- Better integration would involve comparing social learning in children with asocial learning in children and adults, and with both social and asocial learning in 'dumb' animals.
- Mechanisms can be specialized for cultural inheritance by genetic evolution, learning, and cultural evolution.

Introduction

What makes human minds and human lives so different from those of other animals? An increasingly plausible answer is 'cultural evolution'; we are unique in our capacity to learn from others the accumulated wisdom of previous generations (Richerson & Boyd, 2005; Tomasello, 2014). Cultural evolution has been modelled in a number of ways. The basic idea is that much of the knowledge, and many of the skills, used by people across the world today have developed, diversified, and been honed by non-genetic evolutionary processes. These processes are evolutionary because they produce change through heritable variation in fitness. However, the inheritance occurs via social learning rather than genetic mechanisms, and fitness is defined by the number of individuals or groups who adopt a trait through social learning, rather than by the number of biological offspring. If cultural evolution is 'what makes us odd' (Richerson & Boyd, 2005), understanding social learning – the many ways in which learning about animate and inanimate aspects of the world can be influenced by other agents – holds a key to understanding, in an evolutionary context, the peculiarities of human life.

Recently, research on the development of social learning has focused on its selectivity. Infants and children are said to be engaging in 'selective social learning', 'selective imitation' or 'selective trust', or to be using 'social learning strategies', when the extent of their social learning varies with the conditions in which a model is observed, or with characteristics of the model. For example, children show selective social learning when they copy behaviour that had a successful outcome more readily than behaviour that had an unsuccessful

outcome, and when they are more likely to copy a model with high than low social status.

More generally, learning is selective when an agent does not learn from every event or sequence of events to which they are exposed (selectivity of encoding), or when something that an agent has learned is not always manifest in their behaviour (selectivity of expression). It has been known for many decades that both of these kinds of selectivity are fundamental, adaptive features of learning. They are evident even when humble creatures such as rats engage in 'asocial learning' – learning that does not involve other agents. For example, the 'blocking effect' (Kamin, 1969) shows selectivity of encoding, that rats do not learn from every sequence of events they encounter, and experiments on 'latent learning' (Tolman & Honzik, 1930) demonstrate that what a rat has learned is not always expressed in the rat's behaviour.[1]

This evidence, that learning is adaptively selective even in 'dumb' animals, suggests that selectivity does not require great cognitive sophistication, and is very far from being a distinctive feature of human social learning. Therefore, the mere fact that infants and children are selective in their social learning does not indicate that they are smart, or that they are using mechanisms that are specialized for cultural evolution. From an evolutionary perspective, the importance of research on selective social learning lies, not in its capacity merely to demonstrate selectivity, but in its potential to reveal that the selectivity of human social learning is special; that it differs from the selectivity of social and asocial learning in other animals, and asocial learning in humans, in ways that facilitate cultural evolution. If human social learning is special in this sense, the psychological mechanisms that make it special are likely to be adaptations for culture – to have evolved, genet-

ically or culturally, because they promote cultural evolution. Therefore, I suggest, human social learning can be usefully described as 'cultural learning' only when there is evidence that it is based on psychological mechanisms that are specialized for cultural evolution.

At present, the developmental literature on selective social learning is a rich and fascinating source of information about *when* children copy – the contexts in which children are more likely to copy than to perform a previously established behaviour, or to learn a new behaviour through asocial learning – and *who* children copy – the model characteristics, such as age and group membership, that most reliably predict copying. Furthermore, this information is being used in interesting ways to find out about the effects or functions of social learning. For example, it is being used to investigate the extent to which copying serves to establish and maintain social bonds (social function), as well as to promote the development of technical skills (instrumental function; Over & Carpenter, 2013), and to ask whether the selectivity of children's copying makes it especially effective as a means of acquiring culture-specific knowledge (Harris, 2012). However, in this article I suggest that, to meet its full potential – to shed light on human cooperation and evolution – research on selective social learning in infants and children needs to develop in three directions.

First, research on the development of selective social learning needs to distinguish more clearly between functions and psychological mechanisms; between what social learning is doing (function) and how it is done (mechanism). At present, research findings are typically expressed in language that affords both a functional and a mechanistic interpretation. One example, among many, is: 'infants choose not to learn from someone who they perceive as unreliable, and thus, incapable of rational action' (Poulin-Dubois, Brooker & Polonia, 2011, p. 308). This statement could be suggesting that infants copy some models more than others because the infants conceptualize the model as 'reliable' or 'unreliable', 'rational' or 'irrational', and choose to copy the former via a controlled, rather than an automatic process (mechanistic interpretation; Heyes, under review). Alternatively, the quoted passage could be suggesting merely that, through the action of unspecified psychological mechanisms, infants are more likely to copy models that we – adult observers of infant copying, or readers of the quoted article – are inclined to conceptualize as reliable or rational (functional interpretation).

The generic term 'selective trust' is similarly ambiguous. When a researcher describes a behavioural effect as an example of selective trust, are they asserting that it was due to a firm belief in the reliability, truth or ability

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[1] Blocking experiments show that, when they are presented with a sequence in which a compound stimulus precedes an outcome – for example, a light and tone are followed by food – rats and other animals do not learn about the predictive relationship between tone and food if, prior to the compound training, they received training in which the light alone predicted the food. Thus, in blocking experiments animals show selectivity of encoding in that they do not learn about the tone–food relationship when the food is already fully predicted by the light. Similarly, experiments on latent learning indicate that, when they are given a number of opportunities to explore a maze without food reward, rats provide no behavioural evidence that they are learning the lay-out; for example, they do not get faster at running through the maze. However, when food becomes available at the exit, rats that have had the opportunity to explore are able to run faster through the maze than rats that have not had the opportunity to explore. Thus, in latent learning experiments rats show selectivity of expression in that learning does not yield a change in their behaviour until such a change is motivated by the availability of food.

of someone or something (the literal meaning of 'trust'), or that, by virtue of unspecified psychological mechanisms, the children behaved *as if* they had such a belief? This kind of ambiguity is potentially misleading because psychological mechanisms cannot be inferred directly from functions; there is nearly always more than one way in which a cognitive system can produce a behavioural effect. Consequently, I will argue, blurring the distinction between function and mechanism obscures the fact that the design of many comparative and developmental studies to date is such that they can tell us about the functions but not the mechanisms of selective social learning (see Heyes & Pearce, 2015, for a review of research on selective social learning in animals).

Second, to realize its potential, research on the development of selective social learning needs to become more fully integrated with the rest of cognitive science and, especially, with research on asocial learning in humans, and on social and asocial learning in other animals. Cumulative cultural evolution is a distinctively human phenomenon. Therefore, the selectivity of social learning in children can help us to understand the human capacity for cultural evolution to the extent that it depends on special psychological mechanisms; on mechanisms that are present only in humans (or in humans and our close primate relatives), and that are tuned specifically to make social learning selective. However, there is a tendency in current research to assume, rather than to check, that selective social learning in children depends on special mechanisms. The only way to find out for sure is to compare – using existing research and via new purpose-built experiments – the selectivity of children's social learning with the selectivity of their asocial learning, and with the selectivity of social and asocial learning in other creatures.

Third, it should be more broadly recognized that 'genetic evolution' – natural selection operating on genetic variance – is not the only process through which psychological mechanisms can become specialized; they can also be tuned by learning. Therefore, even when we find evidence that selective social learning depends on distinctive psychological mechanisms, tuned to promote the cultural inheritance of information, we need to ask to what extent the specialization is due to genetic evolution and/or to domain-general processes of learning.

In the next two sections of this article I illustrate the approach I am recommending by (1) trying not to elide the distinction between function and mechanism, while (2) examining focal examples of selective social learning in children in the context of other psychological research, and (3) drawing attention to the way in which learning can shape psychological mechanisms. The examples discussed in the next section relate to *when* copying occurs, and those in the following section relate to *who* is copied. I have chosen as focal examples some of the best and most interesting recent studies of selective social learning in infants and preschool children. However, I shall argue that, even among these studies, it is hard to find evidence that selective social learning depends on special psychological processes – that it constitutes 'cultural learning'.

Before continuing, a note on scope and terminology: This article concerns research on the development of selective social learning in which infants and children copy nonverbal behaviour; it does not encompass studies in which they endorse or reject explicit verbal testimony (Sobel & Kushnir, 2013). It is conventional in research on selective social learning to use 'copying', 'social learning', and 'imitation' interchangeably to refer to a very wide range of cases in which the observation of a model's behaviour results in the observer exhibiting similar behaviour. The observer's behaviour may be 'similar' to that of the model in being directed to the same object or location, producing the same effects on objects, involving movement of the same part of the body (e.g. the head rather than a hand), or reproducing the topography of the model's action (the way in which body parts move relative to one another) (see the 'Who' section, below, for some concerns about this inclusive approach). Equating 'copying' with 'social learning' is potentially misleading because some instances of copying involve very little learning (e.g. contagious yawning; Provine, 2005), and social learning can yield dissimilar or 'counter-copying' behaviour (Darby & Riopelle, 1959). However, research on selective social learning does not currently encompass cases where social learning leads to counter-copying, and therefore I shall follow the convention of treating 'copying' and 'social learning' as synonymous. I shall, however, avoid using 'imitation' in the same, broad sense because in closely related literatures 'imitation' refers specifically to copying of the topography of body movement.

When?

When studies of the development of selective social learning examine the conditions in which children are more likely to copy than to perform a previously established behaviour, or to acquire a new behaviour through asocial learning. Typically, in recent experiments of this kind, children have been given the opportunity to copy a model immediately after one of two 'priming' experiences, and the researchers have recorded the frequency of copying responses as a function of the priming treatment. I will focus on two *when* studies,

designed to probe the instrumental (Williamson, Meltzoff & Markman, 2008) and social (Over & Carpenter, 2009) functions of copying, respectively. They are both of considerable interest in their own right but, I will argue, for reasons that apply to a range of *when* studies, they do not tell us whether selective social learning is based on psychological mechanisms that are specialized for cultural inheritance.

Outcome modulation

Williamson *et al.* (2008, Experiment 1) tested 3-year-olds in a procedure with three stages: priming, observation and test. In the priming stage, the children had an easy or a hard task, e.g. to open a drawer that moved smoothly (easy), or a drawer that was jammed with putty (hard) to find a toy inside. In the observation stage, they were encouraged to watch an adult model performing the easy task using a distinctive method, e.g. pressing a small button on the front of a second drawer before opening it smoothly and finding a toy. In the test stage, the children performed the task for a second time but they were all given the easy version, e.g. a third, unimpeded drawer in the same chest. The results showed that, on test, the children who had encountered the hard task at the beginning of the experiment were more likely than those who had encountered the easy task to copy the method used by the model, e.g. to press the button on the front of the drawer.

Williamson and colleagues interpreted these results as showing that young children copy 'selectively' and 'in a rule-governed manner' (Williamson *et al.*, 2008, p. 282). Their findings certainly demonstrated selectivity in that the children were more likely to copy the model in one context (after performing the hard task) than in another, but it is not clear what the authors meant by 'rule-governed' (Heyes, under review). They may have been suggesting that the children's behaviour was guided by an explicitly, and perhaps consciously, represented rule such as 'When the usual method doesn't work, copy a successful method'. This would imply that the children knew the rule and were following it in the way that a cook follows a recipe. It would also imply that the children's behaviour was based on a domain-specific mechanism; on a rule that can be applied only when one has the opportunity to copy another agent's action. Alternatively, Williamson and colleagues may have been suggesting only that the children's copying behaviour could be described by a rule; that, like planetary motion, the children's behaviour exhibited a law-like regularity that was not known to the children themselves. This would imply that the children behaved *as if* they were following a domain-specific rule, but would leave open the question of what was actually going on in the children's minds. Under this interpretation, the rule would characterize a potential function of selective social learning – to promote successful performance when prior learning was ineffective – but not a psychological mechanism mediating this function.

In the study by Williamson and colleagues, the children certainly behaved in a way that can be described by a rule, but we do not know whether the children were following a rule. The selectivity of their copying behaviour could have been due, not to following a domain-specific rule, but to the operation of domain-general psychological mechanisms. Experiments on asocial learning in animals and humans have shown that the mechanisms of associative learning are driven by 'prediction error' – the difference between what was expected to occur after an event (a stimulus or an action) and what actually occurred after the event (den Ouden, Friston, Daw, McIntosh & Stephan, 2009; Schultz & Dickinson, 2000). Broadly speaking, the greater the prediction error, the more the agent attends to (Pearce & Hall, 1980) and learns about (Rescorla & Wagner, 1972) the relationship between the event and its outcome. Therefore, the children in the first experiment by Williamson *et al.* (2008) behaved exactly as one would expect if their behaviour had been based on associative learning: by hypothesis, they attended more, and consequently learned more, when there was a large prediction error at the priming stage – e.g. they expected pulling to result in the drawer opening smoothly but instead it jammed – than when there was a small prediction error at the priming stage – e.g. they expected pulling to result in the drawer opening smoothly and, although the trajectory may not have been exactly as they had anticipated from past experience with drawers, it did indeed open smoothly.

The associative account is also consistent with the results of two further experiments reported by Williamson *et al.* (2008, Experiments 2 and 3). These illustrated another kind of *when* selectivity by showing that 3-year-olds were more likely to copy the model's action if it had been successful (e.g. the drawer opened smoothly to reveal a toy) than if it had been unsuccessful (e.g. the drawer jammed and either no toy appeared, or a toy was subsequently produced from elsewhere). This suggests that 3-year-olds are able to learn action–outcome relationships by observation, and that they are more likely to copy an action that has had a positive outcome. As one would expect if it is based on associative mechanisms, which are known to be present in a broad range of species (Heyes, 2012b; Macphail, 1982), this kind of selectivity has also been found in birds.

Dorrance and Zentall (2002) allowed Japanese quail to observe a conspecific model using a distinctive method to depress a lever, pecking or stepping, when the model's actions were followed by food reward (successful) or had no programmed consequences (unsuccessful). Observers of successful performance subsequently copied their models' behaviour more than observers of unsuccessful performance; they pecked if the model had been pecking, and stepped if the model had been stepping. Replicating and extending this result with pigeons, Saggerson, George and Honey (2005, Experiment 3) found that it depends, not only on stimulus–response (S–R) learning – learning to make a particular response in the presence of a particular stimulus – but also on action–outcome learning by observation. They allowed pigeons to observe a conspecific model performing one action (A1, e.g. pecking) for one outcome (O1) and another action (A2, e.g. stepping) for a different outcome (O2), and then devalued one of the outcomes (e.g. O1) for the observers. Subsequently, the observers preferentially copied the action that, when it had been performed by the model, was not followed by the now devalued outcome (e.g. A2). Thus, like 3-year-old children (Williamson *et al.*, 2008), pigeons can learn action–outcome relationships by observation, and selectively copy those actions that have been associated with outcomes that are of value when the copying occurs.

Copying that is thought to depend on knowledge of action–outcome relationships is often described as 'goal-directed' (Bekkering, Wohlschlager & Gattis, 2000; Over & Carpenter, 2013). The evidence that pigeons show goal-directed copying (Saggerson *et al.*, 2005) is a reminder that it can be based on taxonomically and domain-general associative mechanisms. Therefore evidence that children are capable of goal-directed copying does not imply that they represent the model's intentions (Leighton, Bird & Heyes, 2010) or, more generally, that they are using mechanisms that have evolved in the hominin line for the guidance of social learning.

Social motivation

The second *when* study to be considered in detail investigated the social rather than the instrumental functions of selective social learning; the possibility that selective social learning serves to establish and maintain social relationships, as well as to promote efficient interactions with tools and other features of the inanimate environment. In the priming phase of this study, Over and Carpenter (2009) presented 5-year-olds with videos in which coloured geometric shapes moved around the screen. The 'ostracism group' saw videos that had been judged by adults to depict social exclusion.

For example, the adults judged a distinctively coloured shape to be trying, without success, to join a group of two other shapes. The control group saw videos with similar low-level visual features that were not interpreted by the adults as depicting social exclusion. In the second phase of the experiment, the children had the opportunity to observe an adult model selecting one of three coloured tools, manipulating the selected tool, and moving it over the surface of a box at a distinctive orientation and in a distinctive direction. This sequence of actions was repeated three times, and after each sequence a light inside the box was illuminated. In the final, test phase, the children were offered the tools and the box, and the experimenter recorded their actions on these objects. Careful coding of the children's behaviour showed that, compared with the control group, the ostracism group reproduced more components of the modelled action sequence.

This experiment had many strengths: an ingenious manipulation, exemplary stimulus control, meticulous coding and reporting of the children's behaviour, and an intriguing result. The result is intriguing – it makes one want to know more – because it suggests, but does not demonstrate, that the children's selective social learning was based on distinctively social mechanisms. It makes one think that the children in the ostracism group decided to copy the model's actions more precisely because they were feeling socially excluded, and believed – perhaps not consciously, but at some level – that copying would alleviate this feeling by strengthening their relationship with the model or other social partners. This is a natural interpretation but we do not know whether it is correct because the experiment did not include asocial 'input' and 'output' controls. For example, an input control would compare the effect of the ostracism prime with that of an asocial prime that is equally likely to induce mild anxiety, and an output or 'ghost' control (Heyes, Jaldow, Nokes & Dawson, 1994) would compare the effects of the ostracism and asocial primes on, not only copying of a model's behaviour, but also reproduction of an inanimate sequence of events. Without these controls, we cannot be sure that the ostracism prime had its effect because it engendered thoughts with specifically social content, or that it acted specifically on the children's ability or motivation to copy another agent. Instead, mild anxiety, which can be produced by both social and asocial stimuli, may have made the children more attentive to the events that followed the priming video, and this could have made them better able to reproduce those events whether or not they involved another agent.

If input and output controls revealed that Over and Carpenter's (2009) effect is specific to a social prime, and

that the social prime selectively enhances attention to, or copying of, social stimuli, there would be good reason to believe that, in 5-year-olds, some selective social learning is based on psychological processes that are specialized for social interaction. This would be a very interesting result. However, even with this result in hand, we should not jump to conclusions about how these processes became specialized. Studying children from 2 to 5 years of age in a naturalistic free-play setting, Grusec and Abramovitch (1982) found that copying of both adults and peers was typically followed by social rewards; the model maintained or increased their level of social interaction with the child who had done the copying (see also Bates, 1975). This suggests that children have ample opportunity to learn via domain-general associative processes that copying promotes social interaction, and that this kind of reward is especially valuable when one is feeling anxious or socially excluded (Miller & Thelen, 1986). Therefore, evidence of specialization – that copying occurs more frequently when children are motivated and likely to obtain social rewards – does not necessarily imply that this tendency has been favoured by genetic evolution because it promotes efficient social learning.

Who?

Who studies seek to identify model characteristics that predict copying in children. In a typical experiment, different groups of children are allowed to observe models with different characteristics performing the same actions on objects (observation phase), and the extent to which the children copy the observed actions is assessed in a subsequent period when the children have access to the objects themselves (test phase). Research of this kind has been conducted since the 1960s, but in recent years the choice of model variables has often been guided by the hypothesis that selective social learning functions to promote the cultural inheritance of technologies and other group-specific traits. I shall discuss four *who* studies, each examining a model variable that is relevant to the function of selective social learning: age, group membership, prestige, and reliability. I shall suggest that the results of these studies, like those of other experiments examining the same variables, are broadly consistent with the idea that selective social learning promotes cultural inheritance. However, I shall also suggest that these studies do not tell us whether selective social learning is based on distinctively social mechanisms or, to the extent that they involve specialized social mechanisms, whether the specialization is a result of genetic evolution rather than learning.

Age

Over the past 50 years, a great many studies have indicated that children are more likely to copy older models than peers (e.g. Bandura & Kupers, 1964; McGuigan, 2013). Assuming that older models are more likely than peer models to have knowledge and skills that children lack, this preference suggests that selective social learning is broadly adaptive; it promotes the acquisition of reliable knowledge and effective skills. However, given that humble, culture-free animals, such as rats (Gerrish & Alberts, 1995) and guppies (Dugatkin & Godin, 1993), have also been found to prefer older models, it is clear that a childhood preference for older models does not by itself support the view that human selective social learning is based on psychological mechanisms that are specialized for cumulative cultural inheritance.

A recent study by Zmyj, Daum, Prinz, Nielsen and Aschersleben (2012) attempted to overcome the first of these interpretive problems by testing an unusually subtle and interesting hypothesis about the effects of the model's age on social learning. They predicted that infants would prefer an older model when copying novel actions, because copying novel actions fulfils an instrumental function, but prefer a peer model when copying familiar actions, because copying familiar actions fulfils a social function. In their first experiment, 14-month-old infants observed a video of a peer (14 months old), an older child (3.5 years old), or an adult (22 years old) repeatedly performing a novel 'head-touch' action, i.e. the model touched the top of a box with their forehead and thereby activated a light inside the box. In a subsequent test session, only the infants who had observed the adult model were more likely than controls, who had not seen any action on the light box, to bend their heads towards the box. In the second experiment, infants of the same age received a series of trials in which they first observed a peer, older child or adult model manipulating objects in a familiar way (e.g. putting a stick into a hole in a box, detaching a cube from a dumbbell, placing a loop on a prong), and were then given access to the objects themselves. In this case, it was only the infants who had observed the peer model who were more likely than controls to copy the actions they had observed.

In a balanced and scholarly discussion of their findings, Zmyj and colleagues (2012) freely acknowledged that a number of factors other than the novelty/familiarity of the observed actions could have contributed to the infants' preference for an adult model in Experiment 1 and a peer model in Experiment 2. However, the authors did not discuss an alternative

interpretation of their findings that has, I believe, significant theoretical and methodological implications. This alternative notes that copying in the first experiment involved 'effector matching' (Gillmeister, Catmur, Liepelt, Brass & Heyes, 2008), moving the same part of the body as the model (the head), whereas copying in the second experiment involved 'object matching', producing the same interactions among inanimate objects (e.g. putting a loop on a prong), regardless of the body parts or movements used by the model to achieve these object interactions (Huang, Heyes & Charman, 2006). This contrast between effector matching and object matching is important because it means that attention to the model's body, and particularly to the model's face, would promote encoding, and thereby copying, of the head-touch action (Experiment 1), but discourage encoding, and thereby copying, of the object interactions (Experiment 2). Consequently, it is possible that the infants attended more to the adult model's face than to the faces of the peer and older child models in both experiments, because adult faces had been more informative for these infants in the past (Ferguson & Heene, 2012; Seehagen & Herbert, 2011), and that this attentional bias promoted copying of the head-touch action in Experiment 1, but discouraged copying of the object interactions in Experiment 2. Thus, according to this body/object account, in contrast with the novel/familiar hypothesis, the infants did not 'choose' to copy the adult in Experiment 1 and the peer in Experiment 2 – according to whether they wanted to acquire a novel skill, or on any other basis. Rather, their test performance was a direct reflection of how much attention they had devoted to the test-relevant parts of the display during the observation phase.

The body/object hypothesis is supported by evidence that attentional processes play a major role in determining whether infants copy head-touching (Beisert, Zmyj, Liepelt, Jung, Prinz et al., 2012). Whether or not it turns out to be correct, the coherence of the body/object interpretation suggests that research on selective social learning would be better able to address questions about psychological processes if it distinguished more clearly between types of behavioural similarity. Each type – for example, effector matching and object matching (see final paragraph of the Introduction for a more complete list of types of behaviour similarity) – makes different demands on perception, attention, learning, memory and motor control processes. Therefore, although it may be adequate for some purposes to lump them all together as 'copying', it would be wiser to split them apart if we want to know what is happening in children's minds when they show selective social learning. Turning from theoretical to methodological matters, the coherence of

the body/object hypothesis suggests, not only that attentional measures are important in research on selective social learning, but that they need to differentiate parts of the model display. Although Zmyj and colleagues (2012) conscientiously assessed and reported their infants' attention during the observation phase, the measure they used – time spent looking at the video screen – was not sufficiently fine-grained to distinguish attention to the model's body from attention to the objects on which the model was acting.

Group membership

A number of recent studies have shown that children of 3, 4 and 5 years of age more readily copy familiar than unfamiliar adults (Corriveau & Harris, 2009), and are more likely to copy adults who speak the child's native language with a native accent than with a foreign accent (Kinzler, Corriveau & Harris, 2011). Building on these studies, but testing infants rather than children, Buttelmann, Zmyj, Daum and Carpenter (2013), like Zmyj et al. (2012; see previous section) sought evidence that selective social learning is precisely tuned for cultural inheritance at a young age. They asked whether infants prefer an ingroup model when the to-be-copied behaviour is likely to be characteristic of a group (e.g. a distinctive body movement), but not when it is likely to reflect the idiosyncrasies of an individual (e.g. a preference for one colour or shape over another).

In the study by Buttelmann et al. (2013), each 14-month-old infant was given four trials. In each trial, the infants first observed on video an adult model telling a story in their native language (German; ingroup condition) or in a foreign language (Russian; outgroup condition), then observed the same person performing an action, and were finally assessed for copying of the modelled action. In two trials, the modelled action involved a distinctive body part: the head-touch action, and 'sit-touch' – the model put his buttocks on a box and a light inside the box was illuminated. In the other two trials, the modelled action involved selection of one of two geometric objects, which differed in both colour and shape. The results showed that infants who had observed an ingroup model were more likely to perform the head-touch action than infants who had observed an outgroup model, and a similar trend for the sit-touch action. However, they provided no evidence of copying in either condition in the object selection trials; on test, observers of both ingroup and outgroup models selected objects at chance.

Why were infants who had observed the ingroup model more likely to copy the head-touch action? A psychologically rich answer to this question, tentatively

advanced by Buttelmann *et al.* (2013), would suggest that all of the infants actively compared the model with themselves, and conceptualized the degree to which he was 'similar' or 'like me'. Compared with the infants in the outgroup condition, those in the ingroup condition inferred from language cues that the model was highly similar/like me, and decided on this basis to copy his actions. This rich hypothesis is internally coherent, but it is certainly not the only plausible candidate. A leaner alternative suggests that the infants' attention was drawn more to the body, and especially the face, of the ingroup than the outgroup model because it made pleasantly familiar, rather than scarily unfamiliar, sounds, and that closer attention to the model's body while he was performing the head-touch action promoted encoding of his head movement and thereby the performance of head movement on test. This account implies that the infants did not compare the model with themselves – that they would prefer any model with familiar characteristics, regardless of whether those characteristics were shared by the infant or members of the infant's social group – and is consistent with the looking time data reported by Buttelmann *et al.* (2013). Although these data were not fine-grained, they showed that infants in the ingroup condition looked at the screen significantly more than infants in the outgroup condition while the model was telling a story, and revealed a similar trend when he was modelling the action. The lean interpretation is also consistent with evidence that a preference for familiar models can be produced by domain- and taxon-general psychological processes: both rats (Galef & Whiskin, 2008) and gerbils (Valsecchi, Choleris, Moles, Guo & Mainardi, 1996) have been reported to copy familiar models more than unfamiliar models.

If the object selection trials had provided any evidence of copying, it would also be necessary to explain why, in contrast with the body part trials, they did not reveal an effect of the model's group membership. However, since there was no sign of copying in the object selection trials, it is likely that these trials simply were not suitable for detecting copying, or any modulatory effect on copying, in infants. Buttelmann and colleagues cited a previous study using object selection trials but that study (Thomas, Due & Wigger, 1987) involved 6- to 7-year-old children. Thus, to conclude from the object selection trials that infants are unaffected by, or disregard, the model's group membership when they are copying idiosyncratic preferences would be to confuse absence of evidence with evidence of absence.

This focal example suggests that it is far from ideal to use entirely different tasks (e.g. body part versus object selection) to represent actions that are and are not likely to be characteristic of the child's social group. A more promising approach might be to use multiple models (Fehrenbach, Miller & Thelen, 1979). For example, before testing, all children in an experiment would see four adult models, two with ingroup (I) and two with outgroup (O) characteristics, two performing one action (X) and two performing a different action (Y). One group of children would see group-consistent behaviour (e.g. the ingroup models do X and the outgroup models do Y; IX-IX-OY-OY), while the other would see group-inconsistent behaviour (one ingroup and one outgroup model do X, and one ingroup and one outgroup model do Y; IX-IY-OX-OY). If copying varies with the group membership of models and with the group-specificity of the action, one would expect, with appropriate counterbalancing: children in the group-consistent condition to copy X more than Y; children in the group-inconsistent condition to be indifferent with respect to X and Y; and children in the group-consistent condition to copy X more than those in the group-inconsistent condition. This pattern of results would suggest that selective social learning can function to promote the cultural inheritance of group-specific behaviour but, of course, further research would be needed to find out whether this function is fulfilled by specialized psychological mechanisms and, if so, whether they were tuned by genetic evolution and/or by learning.

Like most designs, the multiple model design would be difficult to implement with infants, which raises the question of why it is important to test for selective social learning in infants. Curiously, articles on selective social learning in infants seldom explain why very young children were chosen for study. I can think of a good reason and a not-so-good reason. The good reason is that it might tell us from what age selective social learning functions in particular ways – for example, to enhance the efficiency of copying in general, or the acquisition of group-specific behaviours in particular. The not-so-good reason hinges on the assumption that, across tasks and types of copying, selective social learning in infants is more likely than selective social learning in older children to reflect domain-specific, genetically inherited psychological processes rather than domain-general processes, or processes that have become specialized through learning. This assumption is not secure because even young infants have had ample opportunity to learn some things about the world, and learning is not a continuous, linear process; after a while, it reaches asymptote so that further experience of the same kind does not lead to further learning. Therefore, in relation to some tasks, infants may have done as much task-relevant learning as older children. Aside from twin studies, probably the best way to assess the extent to which a behavioural trait is genetically inherited is to

look for evidence of 'poverty' (Chomsky, 1976) or 'wealth' (Ray & Heyes, 2011) of the stimulus. This requires that we find out, through naturalistic studies of the kind reported by Grusec and Abramovitch (1982), and training studies, whether research participants – infants, children or adults – have had the opportunity to acquire the trait through domain-general processes of learning prior to the age at which it emerges. The presence of a trait in a young infant does not, by itself, indicate that the trait is genetically inherited.

Prestige

It has been known for some time that children are more likely to copy a model that adults would regard as being of higher, rather than lower, social status (e.g. Bandura, Ross & Ross, 1963; Harvey & Rutherford, 1960) – for example, their head-teacher rather than an equally familiar person of the same age and gender (McGuigan, 2013). Furthermore, recent studies have shown that children prefer models they have observed receiving social approval over those they have observed receiving disapproval or no feedback (e.g. Fusaro & Harris, 2008). Both of these biases are broadly consistent with the idea that selective social learning promotes the cultural inheritance of group-specific behaviour, and it would seem that both could be mediated by domain-general psychological processes. For example, assuming that signs of social approval (looking, smiling, 'That's right', 'Good') are rewarding for a child, when they are repeatedly directed towards a particular person, this pairing could – through an associative process known as 'higher order conditioning' – make the observable features of the person more attractive (Campbell-Meiklejohn, Bach, Roepstorff, Dolan & Frith, 2010). Consequently, the child will pay more attention to that person when they model an action, increasing the probability that the action will be copied.

A recent study by Chudek, Heller, Birch and Henrich (2012) is of focal interest because it seems to show that at least some prestige-based selective social learning cannot be explained by domain-general psychological processes. Chudek and colleagues (2012, Study 2) tested 4- to 5-year-old children in a procedure that began with a priming treatment. In this first phase, the children watched videos in which two models, on either side of the screen, engaged in the same activity, while three 'bystanders' in the middle of the screen were all oriented towards one of the two models, the 'high prestige model'. For half of the children, the artefact group, both models were manipulating artefacts (drawing with crayons or playing with balls and sticks), and for the other half, the eating group, both models were consum-

ing (eating crackers or pouring and drinking water). In the second phase, each child was given two trials, the first involving artefacts and the second involving food. In each trial, the child observed the two models, in succession, making opposing choices between two objects, and was then encouraged to choose between the objects herself. In the first of these trials, the artefact trial, one model chose blocks and the other chose loops to place on a board. In the second, the food trial, one model chose to drink from a white cup and the other from a black cup. Then the whole procedure (priming, artefact trial, food trial) was repeated with different stimuli.

The results showed a trend, across all four trials, for children to copy the high prestige model more when the trial involved the same kind of activity observed during priming. Thus, the artefact group made the same choice as the high prestige model more often in artefact trials than in food trials, and vice versa for the eating group. This prestige × trial type interaction effect was interpreted as showing that the children could not simply have been attending more to the high prestige model as a result of domain-general processes. Instead, their copying behaviour must have been based on a special psychological process (nature unspecified) that has been favoured by genetic evolution because it makes children copy selectively, not only people who are socially approved, but the activities for which they have received social approval.

However, the prestige × trial type interaction observed by Chudek and colleagues can be explained by domain-general psychological processes: research using inanimate stimuli has demonstrated that, when two objects are presented simultaneously and one of them is selectively attended, the other object is subject to 'negative priming' (Tipper, 1985) and 'attentional devaluation' (Raymond, Fenske & Tavassoli, 2003); subsequently it attracts less attention, and is liked less, than the selected object. Therefore, given that the models were presented simultaneously in the priming treatment used by Chudek and colleagues, and that following the bystanders' gaze will have led the high prestige model to be selected during priming, one would expect the domain-general mechanisms mediating negative priming and attentional devaluation to make the children attend more to the high prestige than the low prestige model in the trials that followed the priming treatment. Why did preferential attention to the high prestige model yield more copying only when the trial involved the same activity as the prime? Because, via domain-general processes of incentive motivation, looking at toys during the priming phase made the children want to play, while looking at food and water made them want to eat and drink. Therefore,

in same activity trials, attention to the high prestige model was augmented, rather than counteracted, by the children's motivation state.

This domain-general interpretation of the findings reported by Chudek and colleagues suggests that, although they tested a very interesting functional hypothesis – that selective social learning promotes copying of just those skills for which models have acquired prestige – future tests of this hypothesis should avoid confounding skill type with motivational significance. More broadly, and in common with the other focal studies I have discussed, this one suggests that fine-grain attentional measures are indispensable when investigating the psychological mechanisms, rather than the functions, of selective social learning. It also shows, once again, that we cannot jump to conclusions about genetic causation. There is an extensive literature showing that domain-general processes of learning can have profound effects on attention and thereby on subsequent learning. In both animals and humans, animate and inanimate cues that have in the past reliably predicted outcomes ('learned predictiveness'; Mitchell & Le Pelley, 2010) or been associated with outcomes of high value ('learned value'; Le Pelley, Mitchell & Johnson, 2013) capture more attention in the future, and are therefore learned about more rapidly, than cues that have been less predictive or paired with lower value outcomes. Consequently, even if the results of the study by Chudek and colleagues had implicated specialized attentional processes in selective social learning, a great deal more work would be needed to find out whether these processes had been specialized by genetic evolution or by learning.

Reliability

An especially heterogeneous set of studies has been claimed to show that infants and children prefer 'reliable' models. For example, researchers have categorized as more 'reliable' models those who, prior to demonstrating a behaviour in a focal test of social learning, displayed an appropriate rather than a puzzling emotional reaction, named a familiar object accurately rather than inaccurately, and expressed certainty rather than doubt when naming an object (see Mills, 2013, for a review). This variability is probably due to the fact that, in everyday English, 'reliable' is virtually synonymous with 'trustworthy'. Consequently, in principle, any study that seems to demonstrate an epistemically healthy form of selective social learning could also be said to show a bias in favour of 'reliable' models.

No single case could be representative of such a heterogeneous set. However, brief consideration of one experiment, chosen because the concept of reliability was used with particular prominence in the report, makes clear that at least some research on model reliability is subject to the same interpretative problems discussed in the previous sections of this article. In this experiment (Poulin-Dubois et al., 2011), 14-month-old infants completed four trials in an 'emotional referencing task' before being tested for head-touch imitation. In each trial of the referencing task, the infants saw an adult look into an opaque cylinder, say 'Wow', and display a happy facial expression, and were then allowed to explore the cylinder themselves. In the 'reliable model' condition, the cylinder contained a small toy, and in the 'unreliable model' condition, the cylinder was empty. Infants in the unreliable condition were slower to initiate exploration of the cylinder in the last trial of the emotional referencing task, and less likely to bend their heads towards the light after observing the model perform head-touch responses, than infants in the reliable condition.

A plausible explanation for these results is that the infants in the unreliable condition learned during the referencing task that the model's behaviour was not predictive, or that it predicted outcomes of low value, and consequently attended less to the model's head-touch behaviour in the imitation test. Infants in the reliable and unreliable conditions spent equal time oriented towards the head-touch demonstration but, since this attentional measure was not fine grained, it is possible that the infants in the unreliable condition were attending more to the light box, and less to the model's body, than those in the reliable condition. Indeed, consistent with this interpretation, the results showed that significantly more infants in the unreliable condition succeeded in switching on the light – with head or hands – during the imitation test. The learned predictiveness explanation is also consistent with the results of another experiment in which a 'true belief test', rather than a head-touch demonstration, followed the referencing task (Poulin-Dubois & Chow, 2009). In this case, infants showed more surprise, as indicated by looking time, when a reliable model's behaviour changed (i.e. when she reached for a yellow box after reaching three times for a green box) than when an unreliable model's behaviour changed in the same way (Heyes, 2014)

There is no harm in describing a learned predictiveness, or learned value, effect in terms of 'reliability' as long as we bear in mind that such effects do not necessarily mean that the child has a concept of 'reliability', 'credibility' or 'trustworthiness'. Dumb animals, such as pigeons (Dopson, Esber & Pearce, 2010; Heyes & Pearce, 2015), show these effects, and even those that have been found in adult humans are

explicable by domain-general processes (Le Pelley *et al.*, 2013; Mitchell & Le Pelley, 2010).

Summary and implications

Through close examination of six focal examples, I have highlighted a range of theoretical and methodological issues in contemporary research on selective social learning in infants and preschool children. Viewed in the context of other psychological research – on social learning, asocial learning and attention in human adults and in dumb animals, such as rats and pigeons – all six studies, but especially the first on *outcome modulation* and the last on *reliability*, illustrated the importance of distinguishing functional from mechanistic explanation. In addition, one study suggested that research on selective social learning should differentiate more clearly between types of behavioural similarity (*age*), and four drew attention to the wealth of evidence that psychological mechanisms can be specialized by learning as well as by genetic evolution (*social motivation*, *group membership*, *prestige* and *reliability*). Together, these theoretical points suggest that there is an urgent need for experiments that are designed to find out whether selective social learning is mediated by domain-specific or domain-general mechanisms and, in the former case, to what extent the mechanisms have been specialized by learning. Methods that may be helpful in these experiments include: the use of inanimate input and output controls (*social motivation*); fine-grained measures that distinguish attention to different parts of a model display (*age*, *group membership*, *prestige*, *reliability*); demonstrations involving multiple models (*group membership*); and the kinds of naturalistic and training methods that can reveal poverty or wealth of the stimulus (*group membership*).

In suggesting that there is an urgent need to find out whether selective social learning is mediated by domain-specific or domain-general mechanisms, have I overlooked research that is already probing the mechanisms of selective social learning? I think not. Some recently published surveys (Hoppitt & Laland, 2013; Rendell, Fogarty, Hoppitt, Morgan, Webster *et al.*, 2011) give this impression because they characterize types of social learning (e.g. 'stimulus enhancement', 'contextual imitation', 'emulation') as 'mechanisms' of social learning. However, from the perspective of cognitive science, these types are really 'effects' – behavioural phenomena that call for psychological explanation – rather than mental processes (Heyes, 2012c). For example, 'emulation' is defined as 'Observation of a demonstrator [model] interacting with objects in its environment causes an observer to become more likely to perform any actions that bring about a similar effect on those objects' (Rendell *et al.*, 2011, p. 69). This definition specifies an input–output relationship: observation of X plays a causal role in production of behaviour Y. It does not say anything about why this relationship holds; about what goes in the observer's mind or brain that makes him or her perform actions with a similar effect on the objects. Other putative mechanisms which are sometimes mentioned in connection with selective social learning are theory of mind, shared intentionality (Tomasello, 2014) and natural pedagogy (Csibra & Gergely, 2006; Heyes, in press). In the future, research on these topics may well provide domain-specific hypotheses that can be tested against the kind of domain-general hypotheses highlighted in this article. However, as far as I can tell, at present no research on selective social learning from behavioural demonstrations, rather than testimony (Sobel & Kushnir, 2013),[2] is explicitly comparing domain-specific and domain-general hypotheses, or even acknowledging the possibility that domain-general mechanisms could produce selective social learning.

I have argued in this article that many examples of selective social learning in infants and preschoolers can be explained with reference to the domain-general mechanisms identified by research on associative learning and in other areas of cognitive science (e.g. negative priming and attentional devaluation). My reading of the literature suggests that this is true of all studies to date reporting selective, nonverbal social learning in nonhuman animals (Heyes & Pearce, 2015) and children up to 3 or 4 years of age. It is possible that I have overlooked studies that already provide evidence of domain-specific thinking at this age, and, even if there is no such evidence at present, my analysis certainly does not imply that all selective social learning in older children and adults is explicable by domain-general mechanisms.

Studies of 'expertise' suggest that 5-year-olds may be capable of using domain-specific mechanisms to guide selective social learning. At this age, children are beginning to understand – in a way that cannot be explained by word association alone – that a person's knowledge may cluster around a particular role in

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[2] Just as I have argued that domain-general mechanisms are responsible for selective social learning in nonverbal behaviour, Sobel and Kushnir (2013) have proposed that domain-general mechanisms are responsible for selective trust in testimony. They characterize these mechanisms as processes of 'rational inference', rather than 'association'. To find out whether the rational inference and associative accounts are empirically distinguishable it would be necessary to examine closely, and in the light of contemporary associative learning theory, the evidence that Sobel and Kushnir believe to be incompatible with an associative account.

society (Danovitch & Keil, 2004; Lutz & Keil, 2002). For example, 5-year-olds are able to answer correctly questions about whether a doctor or a car mechanic would know more about a particular topic (e.g. how to mend a broken arm). Consequently, it is possible that 5-year-olds would show selective social learning from doctors and mechanics; a greater willingness to learn from the former when a doll is broken, and from the latter when a toy car is broken. Such an effect would suggest that their social learning was guided by a domain-specific rule – a heuristic that cannot be applied to inanimate stimuli or used to guide asocial learning – such as 'doctors know about bodies'.

Whether or not domain-specific selective social learning develops at around 5 years, there can be no doubt that adults have psychological mechanisms that are specialized for selective social learning. For example, American adults with a degree in the humanities or social sciences – but not graduates in mathematics, science or engineering – judge research to be of higher quality when a summary includes an irrelevant mathematical equation; they are more inclined to trust research presented with 'nonsense math' (Eriksson, 2012). This suggests that, when deciding whether to believe the results of research, people apply a domain-specific rule such as 'maths makes science more precise'.[3]

In both the expertise and nonsense math examples, the domain-specific rule that guides selective social learning is not merely learned, but explicitly taught. Children in societies where there is an appropriate division of labour don't just learn about doctors and mechanics by seeing them at work. They are also told by adults in their social group about these roles and what kinds of knowledge are necessary to fulfil them. Similarly, people in contemporary Western societies learn through formal education to place more trust in research supported by mathematics. Very few people, perhaps only career scientists, have the opportunity to learn through their own experience that, on average, mathematically based research is more reliable. Therefore, the expertise and nonsense math examples raise an interesting possibility: perhaps domain-specific mechanisms of selective social learning not only support the cultural evolution of knowledge and skills, but are themselves culturally inherited (Heyes, 2012a, under review).

According to this hypothesis, the selectivity of social learning in infancy and early childhood is due to domain-general mechanisms, many of them shared with a wide range of other animals. Some of these mechanisms are shaped by learning in the course of ontogeny, and some may even have been primed by genetic evolution, to enhance the efficiency of social learning; to increase the probability that children will acquire through social interaction information that is useful to them. But they are not genetic adaptations for cultural evolution; they have not been favoured by natural selection because they increase the probability that information will be passed from one generation to the next in ways that allow knowledge to accumulate and skills to improve. Domain-specific mechanisms with these functions are among the *products* of cultural evolution. They are based on rules – such as 'doctors know about bodies' and 'maths makes science more precise' – which have been passed down from one generation to the next within a culture, and, through selection processes, honed to improve the fidelity with which other cultural information – e.g. about healing and the objects of science – is inherited. Acquiring rules of this kind depends on language and theory of mind. Children need to be told when trust is considered to be appropriate in their culture, who is thought to be trustworthy on particular topics, and, at least to some degree, about how the mind works (Heyes & Frith, 2014). Consequently, in Western cultures, children do not begin to depend on domain-specific mechanisms of selective social learning until they are about 5 years of age.

Whatever the merits of this hypothesis, I hope this article will encourage researchers to ask whether the selectivity of children's social learning is due to domain-general or domain-specific mechanisms, and, where there is evidence of specialization for cultural evolution – of cultural learning – whether it has been produced by genetic evolution, learning, or cultural evolution. These are tough questions, presenting many theoretical and methodological challenges, but the answers would bring us much closer to understanding what makes human minds and human lives so very different from those of other animals.

Acknowledgements

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[3] According to this hypothesis, all graduates inherit the rule, but the mathematics and science graduates in Eriksson's study understood the formula and therefore realized that the rule did not apply to the research they had been asked to judge.

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