



The planning and execution of natural sequential actions in the preschool years



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ABSTRACT

Preschool children's abilities to learn from observation has been the focus of considerable theoretical and empirical work. A wealth of developmental research suggests that young children reliably over-imitate modeled actions. Across two experiments, we asked whether a single misleading demonstration significantly impacts preschoolers' planning and execution of a familiar event sequence. In Experiment 1, we found that, despite sufficient task knowledge, 3- and 5-year-olds readily incorporated irrelevant modeled actions into their own performances. In Experiment 2, we found that when the underlying event structure was spatially cued, over-imitation was no longer apparent in preschooler's re-enactment of the sequence. These findings serve as evidence for a tight coupling between perceptual and conceptual processing systems in early action planning. Taken together, findings from both experiments suggest that over-imitation behaviour in these tasks results from a failure to evaluate the observed links between procedural components of the sequence in respect to the overarching goal of the task. These results further contrast with the existing developmental literature by suggesting that, in the context of familiar actions, over-imitation significantly decreases during the preschool period. Findings are discussed in the context of preschoolers' abilities to plan and execute sequential actions.

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1. Introduction

Natural actions tend to unfold over extended periods of time in hierarchically structured sequences. Within this hierarchy, higher-level goals are represented at the top level and are composed of more basic goals, which in turn are organised into sub-goals at the next level, descending in this manner to the lowest level (e.g., Grafton & de Hamilton, 2007; Lashley, 1951; Zacks & Tversky, 2001). Successful action planning involves at least some knowledge about how the intended outcomes can be achieved. Thus structuring hierarchical events into discrete goal-directed units plays a fundamental role in determining which components that make up an action sequence are necessary in order to accomplish our goals, and which action features should be left unspecified, thus making fast adaptation to contextual variations possible (e.g., sub-movements of a given action that determine the manner with which the action is carried out). Formal theories in psychology have argued that goal/sub-goal hierarchies are

central to both parsing observed sequences and planning ones' own wilful behaviours (see among others Cooper & Shallice, 2006; Lashley, 1951; Norman & Shallice, 1986; Rosenbaum, Cohen, & Jax, 2007; Zacks & Swallow, 2007; Zacks & Tversky, 2001). In the same vein, several lines of research have argued that imitation of goal-directed actions is fundamentally mediated by hierarchically structured event representations (e.g., Bekkering, Wohlschläger, & Gattis, 2000; Byrne & Russon, 1998). However, little is known about how representational hierarchies are acquired in a way that assures consistent goal attainment while at the same time allowing enormous flexibility in the organisation of sequential actions.

Furthermore, natural everyday actions tend to be embedded into a continuous flow of dynamic goal-directed behaviour. Pauses marking the boundaries of distinct actions are rare (see Asch, 1952; Baldwin, Baird, Saylor, & Clark, 2001; Heider, 1958; Newton & Engquist, 1976). At the same time, natural actions are frequently disrupted mid-sequence by unpredicted events or actions that relate to outcomes other than the primary goal. This discontinuity poses a particular challenge for the parsing of sequences composed of sub-actions with varying degrees of familiarity. In order to learn from the observation of a natural behaviour, actions relevant to specific goals must first be discovered within

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the stream of motion that makes up the event. Equally, goal-irrelevant elements embedded within an observed action sequence need to be identified as such and later disregarded when re-enacting the sequence.

Despite the remarkable abilities that even toddlers demonstrate in parsing complex sequential actions of others (e.g., Baldwin et al., 2001), relatively little is known about the development of action processing during the toddler and preschool years. This gap in the literature is surprising given that this is when children become particularly adept at taking observed behaviour into account in order to achieve internally and externally specified goals.

Within the social domain, a wealth of evidence has spoken to the importance of imitative behaviour as a driving force for the acquisition of cultural knowledge and early appreciations of others' intentions (see Over & Carpenter, 2012, for a recent review). For instance, 3-year-olds reliably imitate the complex structure underlying novel multistep event sequences, indicating a good ability to parse dynamic behaviour systematically and to relate it to goals (e.g., Whiten, Flynn, Brown, & Lee, 2006). Indeed, preschool children appear to reproduce even complex events so consistently that they may include irrelevant elements of the observed behaviour. This sort of indiscriminate imitation, also referred to as over-imitation (Lyons, Young, & Keil, 2007) or over-copying (Whiten, Horner, & Marshall-Pescini, 2005), has been considered a kind of default mechanism by which children learn to perform new actions through observation (Whiten et al., 2005). This line of thinking is further supported by findings from social learning studies in 3- to 5-year-olds (see Horner & Whiten, 2005; McGuigan, Whiten, Flynn, & Horner, 2007), indicating that preschool children will copy a model's actions although some elements of the sequence are clearly irrelevant in order to reach the outcome. Lyons et al. (2007) further demonstrated that a strong tendency to over-imitate modeled actions persists even when preschoolers are specifically asked to perform only the necessary steps of the action sequence and leave "silly extra things" out. The authors suggest that given that causal factors are not always transparent in human actions, blanket copying of behaviour enables children to assimilate new skills even when the underlying causal relations are poorly understood. Indeed, there are good reasons why children should exhibit susceptibility to over-imitation, as copying may facilitate the complex skill acquisition and only occasionally lead to inappropriate actions, which in turn will be corrected later in development (Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009).

Imitation of causally irrelevant actions has been observed to increase from the age of three to five years (McGuigan et al., 2007) and arguably becomes even more reliable with increasing age (e.g., Marsh, Ropar, & Hamilton, 2014; McGuigan, Makinson, & Whiten, 2011; McGuigan, Gladstone, & Cook, 2012). There are various explanations as to why the degree of over-imitative behaviour ought to increase with ongoing development (e.g., Horner & Whiten, 2005; Kenward, 2012; Kenward, Karlsson, & Persson, 2011; Lyons, Damrosch, Lin, Macris, & Keil, 2011; McGuigan et al., 2012). These resemble one another only in the deep divide that they draw between cognitive and social factors.

To avoid confounds with prior event knowledge, over-imitation in adults and children has been explored using novel and relatively abstract tasks. However, as discussed above, in real life settings observers tend to have some prior knowledge regarding the task at hand or may even entertain expectations about events given the context in which they are carried out. As others have noted, when an action sequence is not well understood most sub-actions preceding the outcome are likely to be encoded as causally significant at any point in development (Kenward et al., 2011; see also Williamson & Markman, 2006). Moreover, there is currently no evidence suggesting that either social mechanism or

causal reasoning singlehandedly accounts for over-imitation behaviour in young children and adults. While recently more comprehensive perspectives have been put forth (e.g., Marsh et al., 2014; Over & Carpenter, 2012), an integrative account of over-imitation incorporating contributions from social factors, causal reasoning, and prior knowledge to higher-level event processing is clearly missing.

The primary aim of our first study was to examine over-imitation in the context of a familiar target sequence involving the manipulation of a set of well-known objects. To this end children viewed a pre-recorded video demonstrating a woman preparing a sandwich (the overarching goal) among various goal-irrelevant distractor actions. Thereafter, children were prompted to complete the task themselves. Prior evidence suggests that toddlers are somewhat reluctant to reorganise familiar sequences that are newly modeled in relation to the temporal order in which they are presented (e.g., Bauer & Thal, 1990; O'Connell & Gerard, 1985). It thus appears rather unlikely that when re-enacting a relatively familiar event sequence preschoolers would give up already established representations and exhibit blanket copying of a misleading demonstration. Alternatively, one might expect to observe a trade-off between the preschoolers' reluctance to override existing event knowledge and the tendency to over-imitate modeled actions.

In view of the developmental research discussed above, we predicted that 3- and 5-year-olds would weight the misleading demonstration differently. More specifically, we expected that younger children would struggle to identify irrelevant sub-actions as such and may further show overall greater susceptibility to perceptual influences of the action context (e.g., the array of objects per se). In turn, older children were expected to structure the observed event in terms of specific procedural components and their relative outcomes, and thus disregard irrelevant actions that did not fit the sequential hierarchy.

To preview our findings, we observed that in the absence of a misleading demonstration both 3- and 5-year-olds demonstrated comparable competencies to carry out the familiar target sequence. When, however, children viewed a misleading demonstration prior to task performance clear patterns of over-imitation behaviour emerged in both age groups. Moreover, we found that the tendency to re-enact irrelevant actions decreased during the preschool period. We argue that the ability to assess sequential actions in terms of goal hierarchies is a demanding task even when goal-related elements are well understood.

2. Experiment 1

We presented 3- and 5-year-olds with either a misleading demonstration of the target action (a woman preparing a sandwich) or an unrelated event (a woman wrapping a gift). Experiment 1 thus involved four groups of participants in a 2×2 multifactorial design. Prior investigation confirmed that preschool children are frequently exposed to meal preparing activities, while having negligible experience in carrying out these actions themselves. The extent of children's experience with the target action was further assessed using a questionnaire that parents completed during the test session. The study was approved by the institutional ethics committee and conducted according to the principles of the Declaration of Helsinki.

2.1. Participants

Preschool children's performances were investigated across two age groups: 3 (range = 36–47 months; $M = 40.4$ months;

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