How children learn from and about people: The fundamental link between social cognition and statistical evidence

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Traditional social learning theories lack a unified account of how children acquire rich, abstract causal knowledge from social information. New discoveries showing children's ability to learn abstract causal structure from statistical evidence offer an exciting framework for studying such learning, but social information is conspicuously absent. I propose a fundamental link between social and statistical information through children's developing social cognition. More precisely, young children can – and do – evaluate statistical evidence from human actions in relation to the actions' psychological qualities. Two examples demonstrate the bi-directional nature of this link: the first shows how preschool children recruit their knowledge of psychological constraints on action to infer a physical cause, and the second shows how preschoolers and 20-month-old infants recruit their statistical inference abilities to infer a psychological cause. These studies demonstrate children's impressive ability to learn *from* and *about* people simultaneously, and suggest a mechanism for rapid early learning through social experience. Furthermore, this link implies that statistical inference can be meaningfully integrated with other accounts of social transmission such as imitation, natural pedagogy, and trust in testimony.

People are a critical source of information for young children. Vygotsky (1962; 1978) notably argued that children acquire abstract, conceptual knowledge through social transmission, as evidenced by their ability to demonstrate new knowledge in the context of social interaction prior to attaining individual mastery. Classic and contemporary research in this tradition (Cole, 1971; Bronfenbrenner, 1979; Rogoff, 2003) has confirmed that much of what children learn about the world can be directly attributed to their social environment. However, these socio-cultural theories lack a unified account of *how* children use social evidence to learn. In particular, they do not address Vygotsky's original aim – to understand the role of social information in the development of rich, abstract conceptual knowledge.

A more fruitful approach has been to focus on causal knowledge as the foundation of conceptual development, and causal learning as the process underlying conceptual change (Wellman & Gelman, 1992; Gopnik et al, 2004). New discoveries show that children recruit impressive statistical inference abilities in causal learning; they use probabilities to compute the magnitude and direction of causal effects, and systematically integrate patterns of evidence across observations and actions (Bonawitz et al, 2010; Kushnir & Gopnik, 2005; Schulz, Gopnik & Glymour, 2007). Moreover children do not evaluate statistical evidence in a vacuum; they consider how new evidence fits with their existing knowledge, and revise old beliefs only as evidence mounts against them (Kushnir & Gopnik, 2007; Schulz, Bonawitz & Griffiths, 2007; Sobel, Tenenbaum & Gopnik, 2004). Finally, statistical evidence motivates children's own actions and explanations, and children's exploratory actions in turn generate new statistical evidence (Schulz & Bonawitz; 2007; Schulz, Hooppell & Jenkins, 2008; Legare, in press). Together, these findings demonstrate that young children have "scientist-like" abilities to build causal knowledge. However, the role of social information in this learning process is unknown and unaddressed.

Here I propose a fundamental link between social and causal learning through children's developing social cognition. More precisely, they link through children's burgeoning

understanding of the causes of human actions. Actions provide a special type of statistical evidence critical to causal learning; they are often necessary for disentangling causal directionality and distinguishing between causal relations and spurious associations. In the theoretical framework described above, only the most minimal assumptions about the causes of actions are necessary for causal learning (in brief, they are intentional and manipulative, but see Gopnik et al, 2004 for more details). In reality, however, young children's intuitive causal knowledge of actions is far from minimal – in a few short years they come to understand actions as motivated by goals and desires, constrained by knowledge and beliefs, and much more (Wellman, 1990). This developing knowledge of others – children's social cognition – might be unnecessary (or even distracting) for causal learning. The claim here is rather the opposite, it is vitally important. I propose that young children can – and always do – evaluate statistical evidence from human actions in relation to the actions' psychological qualities. Importantly, considering both social and statistical aspects of actions allows children to acquire knowledge *from* and *about* people simultaneously.

Figure 1 shows a schematic model of this link. Children appreciate that actions are psychologically caused, and that actions cause particular patterns of statistical evidence. Combining these understandings (linking through actions) leads to predictions about learning in both directions. The first prediction is that children recruit knowledge of psychological states to learn about physical causes. The second, and perhaps less intuitive prediction, is that children recruit statistical inference abilities to learn about psychological causes. In the remainder of the chapter, I describe two studies that provide support for each of the predictions above. I conclude by briefly introducing further intriguing (but untested) implications of this proposal. In particular, I suggest this link allows statistical evidence to be meaningfully integrated with other accounts of social transmission such as imitation, natural pedagogical, and trust in testimony.

Learning from people: Children use psychological knowledge to learn a physical cause

By the time children are three they understand that intentional acts are knowledge-driven: actors can be knowledgeable or ignorant (Lutz & Keil, 2002), and situations may or may not allow the deployment of knowledge (e.g., if the actor is acting blindly or otherwise constrained; Gergely, Bekkering, & Kira´ly, 2002). Research shows that young children consider these psychological states when evaluating social and linguistic information (Baldwin & Moses, 2001; Sabbagh & Baldwin, 2001; Koenig & Harris, 2005; Jaswal & Neely, 2006). What about actions? Even accidental acts, or acts born of ignorance, have causal consequences. Thus, when engaged in causal learning, children could very well ignore psychological factors such as knowledge and focus instead on statistical outcomes. Indirect evidence from children's imitation of causal sequences suggests otherwise (Meltzoff, 1995; Gergely et al, 2002; Lyons, Young & Keil, 2002). Kushnir, Wellman & Gelman (2008) attempted to provide a more direct test.

Across three groups of children, Kushnir et al (2008) varied two psychological constraints: whether a source was knowledgeable or ignorant about a novel toy (an epistemic constraint) and also whether the source was permitted to use that knowledge in performing an action (a situational constraint). Three- and four-year-olds saw two puppets. One had expert knowledge of the toy (i.e. "Squirrel knows all about the toy. He knows which blocks make it go") and the other had no knowledge about the toy (i.e. "Monkey has never seen the toy before. He doesn't know which blocks make it go"). Children were then randomly assigned to one of three conditions: 1) the *puppets picked* their own blocks from a large pile, 2) the *child picked* two blocks and handed one to each puppet, or 3) the *puppets picked while blindfolded*. Then, in all conditions, the two puppets placed their blocks on the toy at the same time, activating the toy's musical light. Critically, the actions themselves were unconstrained, equally intentional, and equally associated with the effect, satisfying the minimal criteria to have special statistical properties for causal learning (Gopnik et al, 2004). If children use only these minimal criteria, then they should not prefer one block over the other as the true cause.

The results (Figure 2) show that 3- and 4-year-old children used their knowledge of both epistemic and situational psychological constraints in their causal learning from actions. When asked, "Which block made the toy go?" Children reliably chose the knowledgeable puppet's block only in the *Puppets Pick* condition. Importantly, children understood that even the knowledgeable puppet was subject to situational constraints; when the child chose the blocks, or the puppets chose while blindfolded, children responded at chance.

These findings demonstrate that 3- and 4-year-olds recruit their emerging social cognition to evaluate the informativeness of statistical evidence from actions. Many open questions remain about the extent of this ability, including the way interacts with varying degrees of statistical evidence, the types of social cognitive knowledge that children can recruit for causal learning, and whether developmental differences in social cognition are systematically related to causal learning through this process.

Learning about people: Children use statistical evidence to learn a psychological cause.

Humans acting intentionally—in accordance with their own internal motivations—have the ability to dramatically change statistical sequences of events. This key insight is precisely what makes actions so powerful for causal learning, and, as previously stated, young children share this insight (Gopnik et al, 2004; Schulz et al, 2007). Here I claim an extension of this insight when it combines with real-world social cognition: that recognizing when actions are statistically non-random might allow children to learn about the psychological states of agents. Of course, children might well learn about psychological states solely from psychological cues which accompany actions – eye gaze, reaching, facial expressions, affect, verbalizations, etc – without regard for their statistical regularity or irregularity (refs). Put another way, it is possible that children separately use social information inherent in actions for social learning, and statistical information for causal learning. The previous example (Kushnir et al, 2008) already suggests that this is not always the case, at least not for learning physical causes. In this example,

we examine the link in the other direction, and ask whether children can use statistical evidence to learn about a psychological cause.

Kushnir, Xu & Wellman (2010) investigated whether preschoolers and toddlers use a particular type of statistical evidence – evidence of non-random sampling – to learn about an individual's preference. We first showed 3- and 4-year-olds a puppet ("Squirrel") who selected five toys of the same type from a box (for example, red foam circles). We varied the proportion of toys in the box across three groups of children. In the first group, 18% of the toys were of the selected type and 82% were of an alternative type (e.g. blue foam flowers). In the second group, 50% were of the selected type. In the final group, 100% were of the selected type. After they saw the selection, we asked children to give the puppet "the toy that he likes" out of three possible choices: the selected type (red circles) the alternative type (blue flowers) or a novel type (yellow cylinders). Critically, intentional and affective cues that generally signal preference were identical across conditions, as were associative cues (outcome consistency). Thus, if children infer preferences from psychological and/or associative cues alone, children should give Squirrel his selected object in all three conditions. However, if children consider the whether the sequence of actions shows evidence of non-random sampling, then the stronger the statistical evidence the more likely they should be to infer a preference.

The results (figure 3) show that indeed preschoolers were most likely to infer a preference for the selected object when is was in the minority of objects in the box (18% condition), slightly less likely when the proportions were equal (50% condition) and least likely when it was the only object in the box (100% condition). A modified replication with 20-month-olds showed the same pattern of results. Infants (N=; M=, SD=) saw a female experimenter select five toys of one type out of a box containing a minority of that type (18%) or a majority of that type (82%). Again, social cues were constant and positive across conditions. Nonetheless, infants only inferred a preference when the selected toy was in the minority (pvalue).

These findings show that preschoolers and infants use statistical evidence from actions to learn about a psychological cause. This initial demonstration leaves many open questions for future research on how statistical evidence interacts with other behavioral and effective cues, and how it plays a role in social learning more generally.

Conclusions

This chapter began with the assertion that people are a critical source of information for young children, and that this widely held belief might have a more precise formulation in the context of causal learning from human actions. As shown in the two examples above, very young children consider the social qualities of actions simultaneously with their special statistical qualities. This impressive ability to learn *from* and *about* people simultaneously suggests a mechanism for rapid early learning of abstract, conceptual knowledge through social experience.

More generally, the Vygotskian ideas that motivated this investigation have received a lot of recent attention. A growing body of work [perhaps several examples in this volume?] has given new strength to the claim that social experience is fundamental to learning. Notably, this includes mechanisms of social transmission that clearly influence early causal learning: the ability to imitate goals (Meltzoff, 1995; Gergely et al, 2002; Lyons, Young & Keil, 2002), the ability to read ostensive, communicative cues ("natural pedagogy," Csibra & Gergely, 2009) and the ability to selectively trust other's verbal testimony (Harris et al, in press; Keil 2010). Considering these abilities separately, however, undermines their potential as mechanisms for acquiring abstract knowledge. Imitation supports learning of complex action sequences, and recruits social cognition, but does not address generalization. Natural pedagogy builds abstract learning into imitative learning by positing that explicit ostensive cues are signals to general knowledge, but does not address what sorts of abstract knowledge children might acquire in non-ostensive contexts. Selective trust in testimony, trust that can be based on a broad range of developing social intuitions, is a powerful mechanism for learning social and linguistic concepts. However, it might have very different implications for learning when concrete evidence of causal relations

conflicts with evidence from testimony. Lastly, all of these accounts make predictions about how children learn from people, but not how they learn about them – arguably the most important and early emerging set of conceptual ideas. The link discussed here can be used to unify these approaches and, critically, to integrate them with statistical inference mechanisms already known to drive causal learning. Thus it opens up an exciting new avenue for future research.

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Figure 1: A schematic model of the proposed link between actions as psychologically caused and actions as source of statistical evidence. Learning *from* people (the existing causal arrows in the forward direction) involves using knowledge of psychological states for causal learning. Learning *about* people (a backwards inference, as indicated by the dotted line) involves using statistical evidence to learn about a psychological cause.

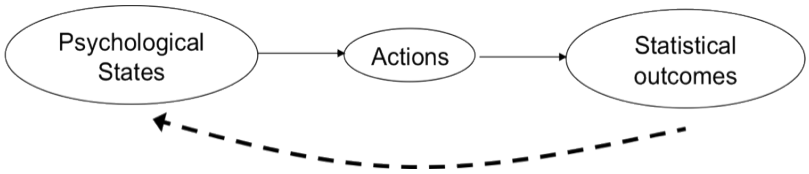

Figure 2: Results of Kushnir et al (2008). The percentage of preschoolers (N=; M=; SD=) choosing the knowledgeable puppets block, the ignorant puppet's block, or both blocks in response to the question "Which block made the toy go?" across the three conditions.

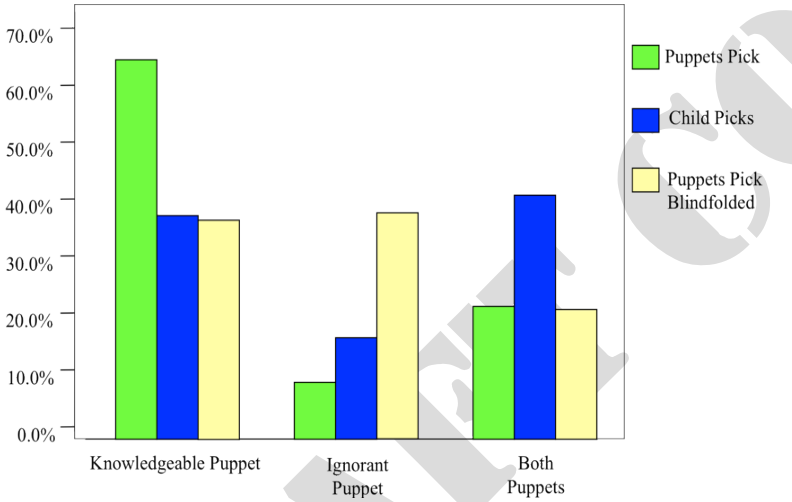

Figure 3: Results of Kushnir et al (2010), Experiment 1. Average number of times (maximum = 2) that preschoolers (N=; M=; SD=) chose to give Squirrel the target toy in each condition. The conditions varied in the percentage of target toys (18%, 50%, or 100%) in the box from which Squirrel sampled 5 target toys. The error bars represent 95% confidence intervals around the means.