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ScienceDirect
Cognition 105 (2007) 184–194
COGNITION
www.elsevier.com/locate/COGNIT

Brief article

Belief–desire reasoning in the explanation of behavior: Do actions speak louder than words? ☆

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Received 13 July 2006; accepted 8 August 2006

Abstract

The mechanisms underwriting our commonsense psychology, or 'theory of mind', have been extensively investigated via reasoning tasks that require participants to *predict* the action of agents based on information about beliefs and desires. However, relatively few studies have investigated the processes contributing to a central component of 'theory of mind' – our ability to *explain* the action of agents in terms of underlying beliefs and desires. In two studies, we demonstrate a novel phenomenon in adult belief–desire reasoning, capturing the folk notion that 'actions speak louder than words'. When story characters were described as searching in the wrong place for a target object, adult subjects often endorsed mental state explanations referencing a distracter object, but only when that object was approached. We discuss how this phenomenon, alongside other reasoning "errors" (e.g., hindsight bias; the curse of knowledge) can be used to illuminate the architecture of domain specific belief–desire reasoning processes.

Keywords: Theory of mind; Explanation; Attribution; Belief–desire reasoning

"If we could do that well with predicting the weather, no one would ever get his feet wet; and yet the etiology of the weather must surely be child's play compared with the causes of behavior" (Fodor, 1987, p. 4).

☆ This manuscript was accepted under the editorship of Jacques Mehler.

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0010-0277/$ - see front matter
doi:10.1016/j.cognition.2006.08.002

According to naïve belief–desire psychology (e.g., Davidson, 1963; Dennett, 1987; Fodor, 1987),[1] agents' actions are caused by two broad classes of mental folk constructs: *beliefs* and *desires*. Davidson (1963) argued that actions are caused by *reasons* – pairings of two types of mental state (or 'propositional attitude'). 'Pro' attitudes, such desires for objects, *motivate* action. 'Cognitive' attitudes constrain the details of that action: where or how it will take place. If we know a person has a reason for a particular action (e.g., the desire for *x* and the belief that *x* is in location A), we can *predict* the action. Conversely, knowing about an action (e.g., search at location A), allows the generation of reasons that might have caused it (e.g., desire for *x* and the belief that *x* is located at A).

Research into our commonsense capacity to understand the actions of others via belief–desire reasoning has been largely undertaken from a developmental perspective (though see also Amodio & Frith, 2006; Saxe, Carey, & Kanwisher, 2004), focusing on the capacity to *predict* actions from information about desires and beliefs. In a classic task (Baron-Cohen, Leslie, & Frith, 1985) preschool participants meet Sally, who leaves her marble in one location before departing, at which time Ann moves the marble to another location. On Sally's return, the child must predict where she will look for the marble. This task shows reliable improvement across the preschool years. Three-year-old children tend to predict that Sally will search in the location actually containing the marble, while 4-year-olds more often predict that Sally will search where she *thinks* the marble is – in the now empty location (Wellman, Cross, & Watson, 2001).

Models of the processes contributing to belief–desire reasoning in action prediction have recently emerged (Friedman & Leslie, 2004a, 2004b; German & Hehman, 2006; Leslie, German, & Polizzi, 2005; Leslie & Polizzi, 1998). However, despite the central importance of *explanation* of action in 'theory of mind', developmental investigations of belief–desire explanation tasks have been few and far between (e.g., Bartsch & Wellman, 1989; Moses & Flavell, 1990; Wimmer & Mayringer, 1998) and studies of belief–desire explanation in adults, models of which must eventually constrain all developmental theories, even rarer.

One framework for interpreting action prediction tasks is the two component theory of belief–desire reasoning proposed by Leslie and colleagues (e.g., Leslie, Friedman, & German, 2004). According to this view, belief–desire reasoning is based in part on a neurocognitive mechanism that takes as input information about the behavior of social agents and generates candidate representations that might have contributed to this behavior. A second mechanism has the task of selecting among the candidate mental states (see German & Hehman, 2006; Leslie et al., 2004; Yazdi, German, Defeyter, & Siegal, 2006, for more discussion). While extensive work has assessed the nature of selection processing in prediction tasks (Friedman & Leslie, 2004a, 2004b; Leslie et al., 2005), the idea that specific mental state representations might be spontaneously generated from information about behavior of social agents

[1] The term 'naïve' is used here to distinguish everyday psychology from products of scientific psychological investigation. As Fodor (1987) argues, everyday psychology is anything but naïve in terms of its success.

has not been tested directly by researchers adopting this framework. However, an extensive literature in social psychology has shown that causal explanations (attributions) of social behavior are often (i) focused on internal dispositions of actors (see Smith, 1994, for a review), and that (ii) inferences about internal traits can be made spontaneously and unknowingly (Winter & Uleman, 1984).

In the experiments reported here, we extend this work to address how specific mental state representations (e.g., belief/desire representations) are generated in response to a specific aspect of social behavior. Adult participants received scenarios based on the false belief task, extended to include the characters' mistaken search. Two types of scenario differed in terms of the mental state representations predicted to be generated in response to the search action. The presence of these different mental state representations in the cognitive system was assessed via requiring subjects to endorse or reject candidate explanations for the search action.

In the experimental scenarios, the false belief scenario was altered by including a second object (hereafter the 'distracter' object) at the location where the character leaves her desired object (hereafter the 'target' object). When the character searches for the target object, her action is directed at a location that contains the distracter object. The control scenarios were identical except that the distracter object was in the second location, such that the character searches an empty location on her return.

We predicted that mental states referencing the distracter object would be generated in the cognitive system in response to the search action, and would enter into the explanation process in the experimental conditions only. In Experiment 1, we tested for the presence mental states referencing desires about the distracter object. This should manifest as errors in *rejecting* this kind of explanation, as compared with endorsing or rejecting other explanations consistent with the story.

Experiment 1

Method

Participants

Sixty five adults (41 females and 24 males, mean age 19) participated for class credit. Participants were randomly assigned to either the 'action toward distracter object' (ADO) condition ($N = 34$) or 'action toward empty location' (AE) condition ($N = 31$). The proportion of males to females in each condition was approximately equivalent.

Design and materials

Participants were presented with a series of 40 text-based reasoning tasks. All tasks consisted of stories involving two agents, two objects and two locations. Each short story described a scenario in which character 1 places a target object in one location and then leaves. At this time character 2 moves the target object to a second location. On her return, character 1 approaches the initial (wrong) location to retrieve the target object. For each task, the story was followed by one candidate

explanation for the mistaken search. Participants' task was to decide as quickly as possible whether the candidate explanation was a correct explanation for the search action. The conditions differed only in the location of the distracter object.

In the ADO condition, the first location also contained the distracter object. Thus, the agent's search for the target object is directed at a location also containing the distracter object. In the AE condition, the distracter object was in the second location. Therefore, the search was directed toward an empty location. An example story from each condition is shown in Table 1.

Four types of candidate explanations were assessed in each condition. Each explained the action in terms of a mental state that character 1 might hold. Two referenced the character's *desire*: one for the target object, the other for the distracter object. The other two explanations referenced the character's *belief* about the target object: a correct (false) belief about the location of the target object and an incorrect (true) belief about the location of the target object. Participants saw just one explanation per story, such that each explanation type was assessed ten times. The candidate explanations associated with the example story appear in Table 2.

Procedure

The 40 tasks were presented in random order via E-Prime (Psychology Software Tools, Inc.) software. Each task began with the presentation of the short story on the computer screen. Participants read the story at their own pace before pressing a key to advance. Next, an explanation question was displayed for 2 seconds (e.g., "Why does Mary go there?"), followed immediately by a screen displaying one of the four possible candidate explanations. Participants were required to press one key to endorse the explanation or another to reject it. Responses and response latencies were collected. Two practice trials preceded the 40 test trials.

Table 1
Example stories for Experiments 1 and 2

Condition	
Action toward distracter object (ADO)	Action toward empty location (AE)
Mary puts her hairdryer *next to her perfume* in the drawer and leaves the room. While Mary is in the shower, Gina moves the hairdryer to the cabinet. Mary comes back into the room for her hairdryer. She goes directly to the drawer.	Mary puts her hairdryer in the drawer and leaves the room. While Mary is in the shower, Gina moves the hairdryer *next to her perfume* in the cabinet. Mary comes back into the room for her hairdryer. She goes directly to the drawer.

Note: Italics highlight the difference between the two conditions.

Table 2
Candidate explanations for Experiment 1

Explanation type	Example explanation
Desire for target (D_T)*	Because she wanted to get her hairdryer from the drawer
Desire for distracter (D_D)	Because she wanted to get her perfume from the drawer
False belief about target (FB_T)*	Because she thought her hairdryer was in the drawer
True belief about target (TB_T)	Because she thought her hairdryer was in the cabinet

* 'Correct' explanation for ADO and AE conditions.

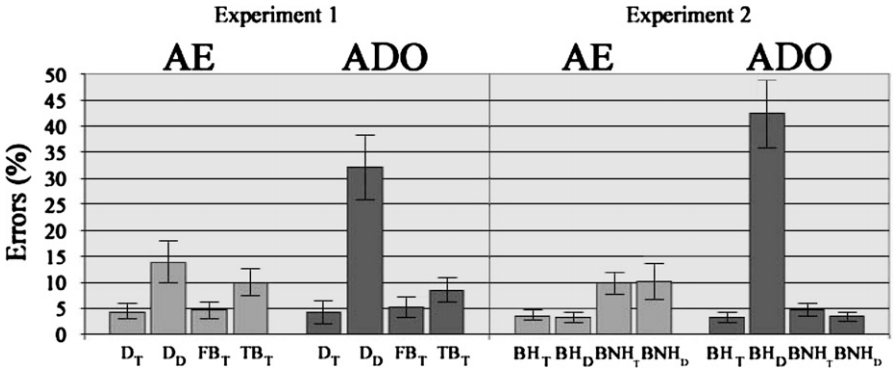

Fig. 1. Mean errors in performance for each candidate explanation according to condition for Experiment 1 (left panel) and Experiment 2 (right panel). For Experiment 1, explanation types were 'desire for target object' (D_T; correct answer = endorse), 'desire for the distracter object' (D_D; correct answer = reject), 'false belief about target object' (FB_T; correct answer = endorse) and 'true belief about target object' (TB_T; correct answer = reject). For Experiment 2 the explanation types were 'belief held about target object' (BH_T; correct answer = endorse), 'belief held about distracter object' (BH_D; correct answer = reject), 'belief not held about target object' (BNH_T; correct answer = reject) and 'belief not held about distracter object' (BNH_D; correct answer = reject). All error bars represent ±1 standard error around the mean.

Results

Responses consistent with the information presented in the story were scored as correct; responses inconsistent with that information were scored as errors. Thus, the correct responses were: endorsing the desire for the target object, endorsing a correct (false) belief about the target object location, rejecting the desire for the distracter object, and rejecting an incorrect (true) belief about the target object location. The converse response for each explanation counted as an error.

The error scores for each explanation type, arranged by condition, appear in Fig. 1 (left panel). Error rates were low for all explanation types in both conditions (*M* error range 4.2–13.9%), the exception being the rejection of the 'desire for distracter object' explanation in the ADO condition ($M = 32.1\%$). This pattern was confirmed in a 2 (condition; ADO vs. AE) by 4 (explanation type; 'desire for target' [D_T], 'desire for distracter' [D_D], 'false belief about target' [FB_T], 'true belief about target' [TB_T]) analysis of variance (ANOVA), with repeated measures for the 'explanation type' factor.[2] There was no overall effect of condition but there was a main effect of explanation type ($F_{(3,189)} = 17.28$, $p < .0001$, $\eta^2 = .22$), qualified by a condition by

[2] The same 2 × 4 ANOVA was conducted on the response time data, with error trials and outliers (defined as response latencies >3 *SD* above the mean) removed. This revealed a main effect of explanation type ($F_{(3,189)} = 17.02$, $p < .0001$, $\eta^2 = .21$) in which the endorsement of correct explanations was faster than the rejection of incorrect explanations.

explanation type interaction ($F_{(3,189)} = 5.01$, $p = .002$, $\eta^2 = .07$).[3] The interaction reflects a greater number of errors when rejecting the D_D explanation in the ADO condition compared to the AE condition.

This result was supported by independent samples *t*-tests for each type of explanation across conditions. Consistent with the ANOVA findings, only the error rate for the D_D explanations differed across the AE and ADO conditions ($t_{(63)} = 2.47$, $p = .02$, $d = .59$). The elevated error rate for rejecting the D_D explanations in the ADO condition indicates that participants reliably *endorsed* this explanation as an acceptable reason for the story character's action.

Discussion

Participants endorsed desire explanations for an object *not* specified as the target of search (the distracter object) when the search was directed toward that object (as in the ADO condition). This suggests that a mental state representation specifying a desire for the distracter object was generated in response to information about the search and entered into the explanation process.

A question remains about the nature of the information generated by the belief–desire reasoning system when an agent approaches an object. One possibility is that the system only creates representations of the character's possible goal – a desire for the distracter object as shown in Experiment 1 – and no other mental state representations accompany it. An alternative is that something akin to a 'reason' in Davidson's (1963) sense is created: a representation of the character's (true) belief about the location of the distracter object may be produced alongside the representation of the desire. This idea is consistent with the proposal that belief and desire information are processed in parallel – a proposal driving some recent models of action prediction (Friedman & Leslie, 2004a, 2004b; Leslie et al., 2004, 2005). This idea is tested in Experiment 2.

Experiment 2

Method

Participants

Seventy six adults (61 females and 15 males, mean age 19) participated for class credit. Participants were randomly assigned to either the ADO ($N = 38$) or AE condition ($N = 38$).

Design and materials

The design and materials were identical to Experiment 1, with the exception of the candidate explanations assessed. Each of the four explanation types was framed as a belief. The object to which the belief referred varied ('target' or 'distracter' object) as

[3] We report partial η^2 throughout.

Table 3
Candidate explanations for Experiment 2

Explanation Type	Example Explanation[a]
Belief held about target (BH_T)*	Because she thought her hairdryer was in the drawer
Belief held about distracter (BH_D)	Because she thought her perfume was in the drawer
Belief not held about target (BNH_T)	Because she thought her hairdryer was in the cabinet
Belief not held about distracter (BNH_D)	Because she thought her perfume was in the cabinet

[a] Example explanations from ADO condition; the location of the objects in the BH_D and BNH_D explanations was inverted in the AE condition.
* 'Correct' explanation for ADO and AE conditions.

did the status of the belief (held by the character or not). The candidate explanations used in Experiment 2 appear in Table 3.

Procedure

The procedure was identical to that used in Experiment 1.

Results

Responses consistent with the explicitly presented story information were scored as correct. Thus, correct responses for Experiment 2 were: endorsement of a (false) belief explanation about the initial location of the target object, and rejections of the other three explanation types. All other responses were considered errors. The error scores for each explanation type, arranged by condition, appear in Fig. 1 (right panel).

The results show that errors rates were low for all explanation types in both conditions (M error range 2.9–10.3%), except when participants were required to reject a belief about the distracter object in the approach location in the ADO condition ($M = 42.4\%$). This was confirmed in a 2 (condition; ADO vs. AE) by 4 (explanation type; 'belief held about target object' [BH_T], 'belief held about distracter object' [BH_D], 'belief not held about target object' [BNH_T] and 'belief not held about distracter object' [BNH_D]) ANOVA, with repeated measures for the 'explanation type' factor.[4] There was a main effect of condition ($F_{(1,74)} = 10.98$, $p = .001$, $\eta^2 = .13$) and a main effect of explanation type ($F_{(3,222)} = 23.43$, $p < .0001$, $\eta^2 = .24$), qualified by a condition by explanation type interaction ($F_{(3,222)} = 37.88$, $p < .0001$, $\eta^2 = .34$). The interaction indicates elevated errors in response to the (true) belief held by the character about the location of the distracter object (BH_D) in the ADO condition only.

This result was further supported by independent samples t-tests for each explanation type across condition. As indicated by the ANOVA, the error rates for the BH_D

[4] The same 2×4 ANOVA conducted on the response time data with error trials and outliers (defined as above) removed, revealed a main effect of explanation type ($F_{(3,222)} = 12.35$, $p < .0001$, $\eta^2 = .14$). This pattern of results stems from endorsements of the correct explanation (the belief held by the character about the target object) being faster than rejections of the other three explanations in both conditions.

explanations differed across the AE and ADO conditions ($t_{(74)} = 6.27$, $p < .0001$, $d = 1.17$). The elevated error rate for rejecting the BH_D explanations in the ADO condition means that participants reliably *endorsed* this type of explanation as an acceptable reason for the story character's action. Error rates in both the 'belief not held about target object' (BNH_T) and 'belief not held about distracter object' (BNH_D) explanations also differed across conditions ($t_{(74)} = 2.56$, $p = .01$, $d = .57$ and $t_{(74)} = 2.09$, $p = .04$, $d = .49$, respectively). However, note that overall error rates for these explanations were low ($M = 3.7$–10.3%) as was the effect sizes of comparison to the AE condition, as compared to the error rate ($M = 42.4\%$) and effect size for the BH_D explanation comparison.

Discussion

Experiment 2 shows that information about a social agent's action provokes the belief–desire reasoning system to generate belief representations that might have contributed to that behavior. When the action is directed toward an object *not* mentioned as the target of search (the distracter object), participants nevertheless endorse a true belief about the location of that object as an explanation for the action. This result, in conjunction with the results from Experiment 1, suggests that the belief–desire reasoning system generates a 'reason' when witnessing an agent move toward an object. Specifically, this 'reason' consists of a desire for that object and a true belief about its location.

General discussion

Belief–desire reasoning has been characterized as comprising at least two kinds of cognitive mechanisms – a representational system that parses observable behavior in terms of possible mental state descriptions and an executive selection system that decides among the candidate mental state representations when explaining or predicting actions (Leslie et al., 2004).

The current experiments address a key prediction derived from the proposed functional role of the representational system using tasks that assess the ability to *explain* social behavior. Because the system is automatic, we predicted that it should calculate candidate mental state representations based on the actions of agents – even if those representations are at odds with the explicitly stated cause of the action. The results demonstrate that the representational system generates candidate belief–desire explanations ('reasons') when presented with information about the actions of a social agent. When the actions of an agent are directed toward a plausible goal object, albeit one that is irrelevant to the scenario described, mental states related to that object are represented and influence decisions about what likely caused the observed action. Specifically, a desire for the object and a true belief about its location are calculated. When equivalent situations containing the same agents, locations and objects are used, but when the

action is directed instead at an empty location, mental states referencing that irrelevant object do not influence the explanation process.

We have characterized the mental state representations about the distracter object as being generated when the agents' actions were described. However, it is possible that the representations were calculated when the explanation probes appeared. Though the current studies cannot resolve this issue, evidence using an explanation production paradigm suggests that 3–5-year-old children and adults will explain a search action in terms of mental states referencing approached distracter objects (German, 1995; Wertz, Levinger, & German, 2006, in preparation).

The notion that folk psychology includes attribution of mental states to agents is neither unknown nor new (Heider, 1958; Heider & Simmel, 1944). In fact, the field of attribution research takes this notion as a starting point and focuses on the more general dynamics of all agent-centered attributions (e.g., the fundamental attribution error; Jones & Davis, 1965; Smith, 1994; spontaneous trait inferences; Winter & Uleman, 1984). Our findings address how mental states—a specific class of agent-centered attributions – are generated in response to observed units of behavior.

The current findings are also complimentary to evidence for infants' early reasoning about agents in terms of the principle of 'rational action' (Gergely, Nádasdy, Csibra, & Bíró, 1995). A central tenet of this theory is that infants attribute goal states in situations where observable patterns of motions and their end states conform to principles of rationality, given the observed layout of obstacles in the world. Repeated motion toward an identified end-state is a critical determinant of the infants' decision about whether that entity is goal-directed.

The phenomenon we report here of 'errors' in adult reasoning during explanation of behavior is consistent with research identifying biases that influence adult 'theory of mind' performance, such as the 'hindsight bias' (Bernstein, Atance, Loftus, & Meltzoff, 2004; Fischhoff, 1975), the 'curse of knowledge' (Birch & Bloom, 2004) and limits on the effective deployment of 'theory of mind' (Keysar, Shuhong, & Barr, 2003). However, biases such as these should not be thought of as errors in the sense that they might be considered to reveal 'sub-optimal' performance. Instead, they should be treated as windows into the design and functioning of the cognitive mechanisms that underlie our capacity to reason about mental states. In ecologically valid contexts it makes sense to consider a social agent's behavior as testament to their underlying beliefs and desires, in addition to the assumptions or assertions about those states available prior to the event. Indeed, the current evidence suggests that the folk principle – 'actions speak louder than words' – is so sensible as to have been incorporated into our cognitive architecture.

Acknowledgements

Thanks to April Blazer, Kimberly Burke, Emily Durrant, and Katherine Levinger for assistance in conducting these experiments and members of the Cognition and Development Laboratory and the Center for Evolutionary Psychology at UCSB for

helpful discussions. Special thanks to David Pietraszewski and Nancy Collins for comments on a previous draft of this manuscript. T.P.G. was supported by a grant from the UCSB Academic Senate.

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