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The domain specificity and generality of mental contamination: Accuracy and projection in judgments of mental content

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In this study we examined individual differences across two tasks requiring people to judge the mental contents of the minds of other people—an opinion prediction task and a knowledge prediction task. The tendency to overproject one's own mental contents in both of these tasks has been interpreted as an instance of mental contamination by Wilson and Brekke (1994). Results demonstrate no domain generality in the process of projecting one's own internal states onto predictions about the internal states of others. Furthermore, projection was efficacious in the opinion prediction task but not in the knowledge prediction task. The differing consequences of mental contamination across these tasks was moderated by the presence of other diagnostic cues that were negatively correlated with the diagnosticity of one's own mental contents in the knowledge prediction task but not in the opinion prediction task. Mental contamination was largely unrelated to cognitive ability or to styles of epistemic regulation. However, predictive accuracy (and its primary determinant—use of other diagnostic cues) was correlated across the two tasks, and was also related to cognitive ability and styles of epistemic regulation. The results are interpreted within the context of two-process models of cognitive functioning (e.g. Evans & Over, 1996; Sloman, 1996).

Several investigators (e.g. Arkes, 1991; Wilson & Brekke, 1994) have distinguished two types of reasoning biases: those that result from the failure to consciously use or know a normative rule and those that result from the operation of automatic heuristic processes. Here we adopt Wilson and Brekke's (1994) terminology of *mental contamination* to refer to the second class of biased processing, where 'people's judgments, emotions, or behaviors go awry because they are 'contaminated' by automatic processes and, in some cases, by the controlled processing triggered by automatic processes' (p. 126).

In the present study, we examined individual differences in two different types of biases that Wilson and Brekke (1994) interpreted as instances of mental contamination—the false consensus effect (Ross, Greene, & House, 1977) and the

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'curse of knowledge' effect (Keysar, Ginzel, & Bazerman, 1995). Both of these were classified as source confusion effects by Wilson and Brekke (see their Appendix B).[1] They both purportedly represent biased processing deriving from automatic overprojection of one's own mental contents. Neither task situation has an explicit normative rule that can be consciously applied. The first bias is demonstrated in studies in the social perception literature where people are thought to overproject their own opinions and attitudes onto the predictions of the opinions of others. The second bias (which we will term the knowledge projection effect, see below) is demonstrated in experiments that show that peoples' estimates of what other people know are largely anchored in what they themselves know (Nickerson, Baddeley, & Freeman, 1987).

By examining individual differences across these two effects, we hoped to investigate three heretofore little-studied issues in the literature on mental contamination in general and on these biases in particular. The first is the issue of the assumed inefficacy of these two projection effects. Hoch (1987) and Krueger (1998; Krueger & Zeiger, 1993; see also Dawes, 1989, 1990) have raised the issue most forcefully in the false consensus literature—questioning whether it is always correct to view the projection of one's own opinion in the consensus paradigm as necessarily 'false'. We are unaware of similar analyses being applied to the analogous knowledge projection experiments (e.g. Nickerson *et al.*, 1987), but the normative issues raised by Hoch (1987) and Krueger (1998) apply equally there.

The second issue that we were able to examine was that of the domain generality of mental contamination across these two tasks. Previous research involving tasks where participants were trying to perform in accord with specific normative rules has uncovered some degree of domain generality in susceptibility to reasoning biases (Rips & Conrad, 1983; Sá, West, & Stanovich, 1999; Slugoski, Shields, & Dawson, 1993; Stanovich, 1999; Stanovich & West, 1998b). The question here was whether there would be domain generality in susceptibility to mental contamination across tasks in which the reasoning bias purportedly results from the operation of automatic heuristic processes (see Krueger, 1998) of overprojection of personal knowledge.

The third issue that we address is the assumption that the type of mental contamination demonstrated in these two tasks arises from automatic processing. Unlike previous examinations of this issue (see Krueger, 1998 for a review), we tested this indirectly through an individual difference analysis. We make the assumption —common in the literature on individual differences and in the literature on two-process models of cognition (e.g. Evans & Over, 1996)—that analytic processing is more closely related to cognitive ability than is heuristic processing (McGeorge, Crawford, & Kelly, 1997; Reber, 1993; Reber, Walkenfeld, & Hernstadt, 1991; Stanovich, 1999). Thus, if the overprojection of information that leads to mental contamination in the opinion prediction and knowledge prediction tasks is due to a

[1] They are classified by Wilson and Brekke (1994) as instances of mental contamination because it is assumed that any type of source confusion represents an unwanted aspect of a person's cognition. Other views in the heuristics literature (e.g. Evans & Over, 1996; Sloman, 1996) put less emphasis on the notion of 'unwanted' influence on processing yet still emphasize the importance of heuristics and automatic processes as a source of biased processing (as opposed to the conscious use of an incorrect rule). We will retain the term mental contamination from Wilson and Brekke (1994), although the differences between their view and those of other heuristic processing theorists (e.g. Sloman, 1996; Stanovich, 1999) have no implications for the conclusion drawn here.

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heuristic process, then we might expect negligible correlations with cognitive ability. If the assumption that projection is a heuristic process is incorrect, however, we might expect significant correlations with cognitive ability because many biases that result from analytic processing—from the failure to employ an explicit normative rule or from the tendency to employ an explicit non-normative strategy—have been shown to correlate with cognitive ability as well as with questionnaire measures of styles of epistemic regulation (Sá *et al.*, 1999; Stanovich, 1999; Stanovich & West, 1997, 1998a, 1998b).

Two knowledge projection paradigms

The phenomenon of false consensus arose within the social prediction literature (Krueger, 1998; Marks & Miller, 1987; Mullen *et al.*, 1985; Ross *et al.*, 1977). False consensus refers to the robust tendency for people to project their own opinions, attitudes, and behaviours when predicting those of others and it has traditionally been viewed as a non-normative response tendency. Operationally, the traditional between-participants false consensus effect has been defined as occurring when participants' estimates of the prevalence of their own position exceed the estimate of its prevalence by participants holding the opposite position (see Marks & Miller, 1987). The false consensus effect has usually been thought to arise at least in part from egocentric attributional biases (Gilovich, 1991; Marks & Miller, 1987; Ross *et al.*, 1977), but the important aspect that it has in common with the second task we examined was that it results from the projection of internal information available to the participant onto the mental contents of others.

Our second paradigm shared this property but involved contamination by knowledge rather than opinion. Knowledge contamination occurs when a person becomes overly anchored in their own knowledge base when the task requires an estimation of what someone else knows, and it has been demonstrated in a remarkably diverse body of literature (e.g. the literature on hindsight bias, Fischhoff, 1975; Haslam & Jayasinghe, 1995; Hawkins & Hastie, 1990; and research on 'curse of knowledge', see Camerer, Lowenstein, & Weber, 1989; Keysar *et al.*, 1995).

The knowledge projection paradigm that we will examine here was chosen because it embodies an experimental logic virtually identical to the opinion prediction experiment mentioned previously. It is exemplified in the experiment by Nickerson *et al.* (1987) in which they presented their participants with a series of general knowledge questions and had them estimate the percentage of people who would correctly answer each question. The results of this study directly mirrored the empirical findings in the social perception literature. Participants who knew the answer to a given question estimated a higher percentage correct response rate in the population than did those participants who did not know the correct answer.

The normative issue: the projection/accuracy relationship

Recent analyses of the false consensus effect have suggested that the interpretation of the tendency to project one's own opinions onto the mental contents of others as a non-normative bias was unwarranted. The discrepancy between the interpretation in

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the original research on this paradigm and the recent empirical work arises not from outright empirical contradictions but rather from the use of alternative statistical analyses to examine the effect (in particular a change from between-participants within-items analyses to within-participants between-item analyses).

Alternative analyses by Dawes (1989, 1990), Hoch (1987), and Krueger and Zeiger (1993) have all demonstrated that some degree of opinion projection is normatively justified because, in the simplest sense, most people are in the majority most of the time. Thus, mental contamination of social judgments by one's own opinion will facilitate predictive accuracy for most people. We will illustrate Hoch's (1987) analysis because we used his parameters to analyse the results of the study reported here.

Hoch (1987) utilized a Brunswikian analysis of the performance of individual participants aggregated across items to demonstrate that some degree of opinion projection is in fact efficacious in the social judgment experiment. Hoch's (1987) analysis begins by defining the following parameters (see Table 1 for summary of parameters): for any given item, T represents the *target position*—the actual percentage agreement in the target population; O represents *own position*—the participant's own agreement with the item (scored 0/1); and P represents the *prediction*—the participant's prediction of the percentage of agreement in the population. One index of predictive accuracy is thus $r(\mathrm{T}, \mathrm{P})$: the correlation, across items, between the actual percentage agreement in the target population and the participant's prediction of the level of agreement in the population.

Table 1. Focal task parameters

Parameter		Opinion prediction task	Knowledge prediction task
T,	Target position	Actual percentage of agreement in the target population	Actual percentage of knowers in the target population
O,	Own position	The participant's own agreement with the item (scored 0/1)	The participant's own knowledge of the answer to the item (scored 0/1)
P,	Prediction	The participant's prediction of the percentage of agreement in the population	The participant's prediction of the percentage of knowers in the population
Z,	Other factors	Other diagnostic cues used by the participant in their estimations	Other diagnostic cues used by the participant in their estimations

Hoch (1987) found that most participants did indeed have positive correlations between their own opinion (O) and the target position (T)—i.e. $r(\mathrm{T}, \mathrm{O})$. The existence of a correlation between own position and target position for most participants means that one's own position is a diagnostic cue that could potentially be used to increase accuracy in predicting the target percentage (T). A final parameter is calculated in Hoch's (1987) analysis: the reliance on other factors in making one's predictions (Z). The 'other factors' parameter, Z, is estimated from the residuals

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when predictions (P) are regressed on own opinions (O). The residuals are thus the variance in predictions not explainable by the participant's own position and presumably are composed of other information on the target opinions that the individual possesses (plus error variance). Any systematic variance in the residuals that correlates with the target values represents the use of other diagnostic cues to improve predictive accuracy. Thus the use of other diagnostic cues can be indexed for each individual by correlating the actual target value for each item (T) with the participants derived Z values— $r(\mathrm{T}, \mathrm{Z})$.

How much participants project their opinions can be indexed by the correlation between prediction and own position, $r(\mathrm{P}, \mathrm{O})$, which we will hereafter term the projection index. In a previous investigation (Stanovich & West, 1998b) the correlation value for the projection index was of moderately high size (.464), but it was in fact lower than the mean correlation between own opinion and target values (r,(T, O)) in the sample (.532). The consequence of projection on predictive accuracy can be indexed by examining the correlation between the degree of perceived consensus ($r(\mathrm{P}, \mathrm{O})$) and the resulting predictive accuracy ($r(\mathrm{T}, \mathrm{P})$, i.e. $r(r(\mathrm{P}, \mathrm{O}), r(\mathrm{T}, \mathrm{P}))$. Hoch (1987) and Stanovich and West (1998b) obtained a positive correlation between these two indices, suggesting that rather than hampering predictive accuracy, projection facilitated accuracy.

We will also utilize a projection index introduced by Krueger and Zeiger (1993). They suggested that an index of over- (false consensus) or under- (false uniqueness) projection at the individual level that is relative to the actual consensus achieved (what they termed a 'truly' false consensus effect) can be derived by correlating, for each participant across items, own position (O, scored as 0/1) with the difference between the actual target percentage and the predicted target percentage (P minus T). Whereas positive scores on this index reveal *over*projection, negative scores reveal underprojection.

Domain specificity and generality in projection of opinion vs. knowledge

The performance indices introduced by Hoch (1987) and Krueger and Zeiger (1993) for analysing the opinion prediction experiment have not been applied to the knowledge projection paradigm, yet the logic of the latter is virtually identical (see Table 1 for a comparison of the parameters across the two tasks). It yields data conducive to the estimation of exactly the between-participants, across-items parameters that Hoch (1987) illustrated for the opinion prediction experiment. Yet the normative issue of whether projection of knowledge increases predictive accuracy remains unaddressed in the knowledge projection paradigm. For example, although the Nickerson *et al.* (1987) experiment provided a demonstration of a between-participants knowledge projection effect, like the early work on consensus effects, their experiment did not directly address the question of whether projecting knowledge facilitated or interfered with predictive accuracy.

A further important issue raised by a direct examination of performance across both tasks is the issue of domain generality. Nickerson *et al.* (1987) seem to have implied some degree of domain generality in mental contamination by arguing that people have a general tendency to overestimate the commonality of their knowledge,

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opinions, attitudes, and beliefs. As mentioned above, although previous research involving tasks where participants were trying to perform in accord with specific normative rules has found some degree of domain generality, we do not know if there would be similar domain generality in susceptibility to mental contamination. This is because the latter (unlike the former) is purported to result from automatic processes operating outside of awareness and outside of explicit conscious control (Wilson & Brekke, 1994).

Individual difference variables

An additional way to explore similarities and differences across the two task types is to examine their correlations with individual difference variables. We employed measures of cognitive ability and measures of intentional-level psychological dispositions related to epistemic regulation that have been shown to relate to the extent of cognitive bias when the bias results from analytic processing—from the failure to employ an explicit normative rule (e.g. Larrick, Nisbett, & Morgan, 1993; Rips & Conrad, 1983; Stanovich, 1999; Stanovich & West, 1998b). We might expect two of the Hoch indices to correlate differently with these individual difference variables if we make the assumption that projection (indexed by $r(\mathrm{P}, \mathrm{O})$) results from an automatic process, whereas the use of other cues (indexed by $r(\mathrm{T}, \mathrm{Z})$) is more likely to result from controlled, analytic processing. Under the assumptions of most two-process theories of cognition (Evans & Over, 1996; Reber, 1993; Stanovich, 1999) individual difference variables would be expected to correlate more with the latter than the former. This conjecture will be examined by triangulating patterns of covariance both within and between the judgment tasks.

Method

Participants

The participants were 123 students (54 males and 69 females) recruited at a large Canadian university. Their mean age was 21.8 years (SD = 3.7) and the modal age was 19. Participants were recruited through poster advertisements distributed on campus. Participants were paid $20 for their cooperation.

Mental contamination tasks

Opinion prediction task. Participants were presented with 30 statements used in previous consensus judgment research (e.g. I think I would like the work of a school teacher; My daily life is full of things that keep me interested). Four items were taken from Campbell (1986), 16 from Dawes (1990), 16 from Hoch (1987), and 4 from Sanders and Mullen (1983). The task consisted of two parts separated in time by other tasks. In the first part of the task participants were read the following instructions by the experimenter:

> I'm going to read you several statements. After I read each statement I'll ask you to estimate what percentage of the students participating in this study (all undergraduate U of T students like yourself) would agree with the statement (on a scale ranging from 0% to 100%).

Each statement was then read by the experimenter. The first statement was followed by the clarifying question 'What percentage of the students participating in this study do you think agree with this statement?' Participants' estimates were promptly recorded by the experimenter.

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Later in the second part of the task, participants were given a form which consisted of the same 30 statements. Participants read the following instructions: 'Please read each of the following statements. Indicate your personal level of agreement (or disagreement) for each on the below scale.'

For each statement participants indicated their degree of endorsement on a 4-point scale: strongly agree (scored as 4), agree (3), disagree (2), strongly disagree (1).[2] Analyses were performed using both the original 4-point scale and a derived dichotomous scale (i.e. nonendorsers vs. endorsers). Both scales demonstrated similar results and thus we report only the analyses using the traditional dichotomous response scale. The items elicited a wide range of levels of agreement and perceived consensus (see Fig. 1).

Knowledge prediction. The knowledge prediction task was designed to be analogous in structure to the opinion prediction task and was adapted from the work of Nickerson *et al.* (1987). In the first part of the task, participants were asked to answer several general knowledge questions read outloud by the experimenter. The task began with the experimenter reading outloud the instructions that follow:

> I'm going to ask you to answer some factual knowledge questions. They range from fairly easy to difficult. All questions require only one word answers. Guessing is encouraged when you are unsure about an answer. There is no time limit, but answer as quickly as possible. If you don't know, just say 'pass' and I'll move to the next question. Are you ready?

The experimenter scored the participant's answer to each question as correct or incorrect. No feedback was given to the participant at this question and answer stage of the task.

In the second part of the experiment, which immediately followed the first, participants were read the instructions that follow:

> I'm going to read you all the questions again. This time I'll ask you to estimate, for each question, what percentage (0% to 100%) of the students participating in this study, all undergraduate U of T students like yourself, you think will get each of the questions correct. For each question, I'll also let you know if you answered it correctly or incorrectly.

Prior to giving each estimate, participants were told whether they had answered the question correctly or incorrectly.[3]

A total of 30 questions were drawn from a pool of normative data collected previously on 300 general-information questions (see Nelson & Narens, 1980). These questions covered a variety of topics associated with various levels of difficulty (e.g. What is the name of the largest ocean on Earth? What is the name of the river on which Bonn is located?). The obtained probability of correct response associated with each item as reported in Nelson and Narens (1980) was utilized here as an index of item difficulty in the selection of the 30 questions used in this task. Easy, medium and difficult questions were equally represented in order to minimize any floor and ceiling effects in individual performance (see Fig. 1). For the same reason it was also determined that the questions should cover a variety of categories. The questions were drawn from five categories which did permit the above conditions: history, geography, general, nature and entertainment. Six questions for each above category were drawn

[2] The ordering of prediction of others' opinions followed by indication of one's own opinion is not a necessary component of the opinion prediction task. The logic of the task is not changed in anyway by reversing this ordering. However, pilot data with the task showed that participants were more likely to get confused about what they were asked to do under the second possible task sequence (i.e. indicating own opinion first, then prediction of others). After indicating own opinion first, participants displayed a tendency to interpret the second part of the task as requiring them to estimate what percentage of people would estimate that the participant personally would endorse the opinion. We sought to avoid this problem completely with the ordering we choose.

[3] Intrinsic to the nature of the opinion prediction task is the availability of a dichotomous-type cue, viz. do I endorse or not endorse this statement. This dichotomous cue is not a necessary component of the knowledge prediction task. On the knowledge prediction task, participants may have varying degrees of confidence that their answer to the questions are correct, but this corresponding own position cue does not assume the clear-cut dichotomous nature found in its respective counterpart in the opinion prediction task. Because we sought to make the two tasks as analogous as possible, we provided our participants with feedback (prior to their estimates) of whether they provided the correct answer to a question. By providing this feedback, participants are in the position to make use of a dichotomous cue, viz. I knew vs. I did not know the answer to that question—the analogue of the endorse vs. not endorse own position cue in the opinion prediction task.

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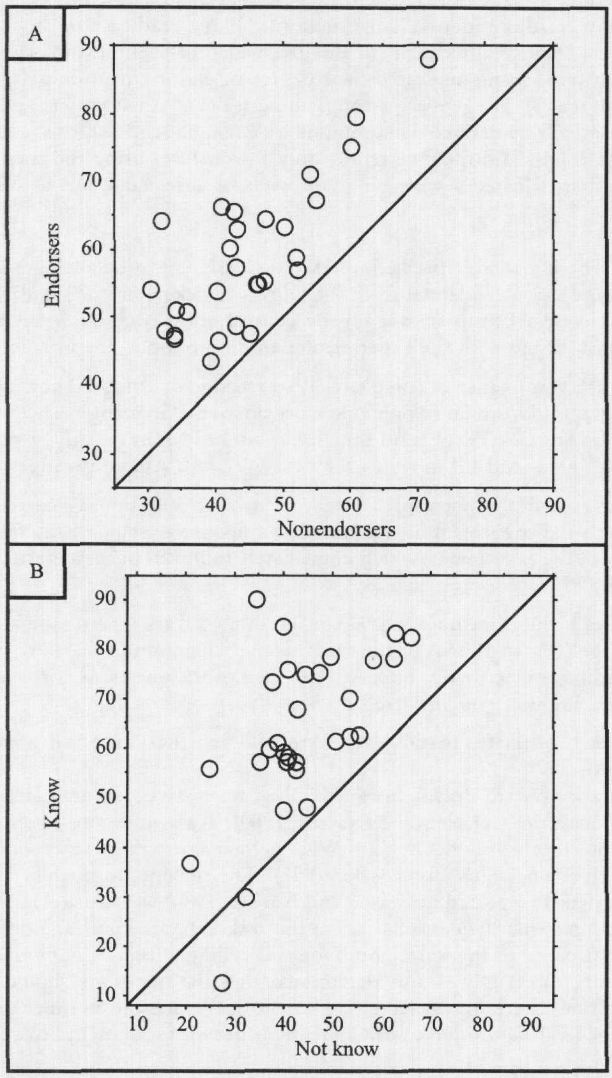

Figure 1. Plots of the mean estimates given by item endorsers and item nonendorsers for each opinion prediction item (Panel A) and the mean estimates given by participants who know the answer to a question for each knowledge prediction item (Panel B).

for a total of 30 questions. Within each of the five categories, two of the six questions were stratified into a further grouping level of easy (probability of correctly answering around .75), another two into medium (probability ~ .50) and the last two into difficult (probability ~ .25).

Cognitive ability measure

Participants completed the Vocabulary and Block Design subtests of the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981). Because these two subtests attain moderate (Block Design)

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and high (Vocabulary) correlations with the Full Scale IQ score, respectively, scores on these two subtests can be prorated to obtain a popular short-form IQ score with high reliability and validity (Sattler, 1988). Using Sattler's (1988) formulas, we derived a prorated IQ score for each participant. The mean of this variable in the sample was 108.3 (SD = 11.7).

Participants also completed a second verbal ability measure and a second non-verbal ability measure. The latter consisted of 18 problems from Raven's Advanced Progressive Matrices (Set II, Raven, 1962). The participants were given 15 minutes to complete the 18 items on the test. By eliminating 12 of the easiest problems, where performance in a university sample is near ceiling (Carpenter, Just, & Shell, 1990; Raven, Court, & Raven, 1977), and six of the most difficult problems where performance is nearly floored (Carpenter *et al.*, 1990; Raven *et al.*, 1977) a cut-time version of the Advanced Matrices is created with nearly the same reliability as the full test (Cahan & Cohen, 1989; Stanovich & Cunningham, 1992).

The verbal measure was a brief vocabulary measure (again, because vocabulary is the strongest specific correlate of general intelligence, see Matarazzo, 1972). This task employed the checklist-with-foils format that has been shown to be a reliable and valid way of assessing individual differences in vocabulary knowledge (Anderson & Freebody, 1983; Stanovich, West, & Harrison, 1995). The stimuli for the task were 40 words and 20 pronounceable nonwords taken largely from the stimulus list of Zimmerman, Broder, Shaughnessy, and Underwood (1977). The words and nonwords were intermixed via alphabetization. The participants were told that some of the letter strings were actual words and that others were not and that their task was to read through the list of items and to put a check mark next to those that they knew were words. Scoring on the task was determined by taking the proportion of the target items that were checked and subtracting the proportion of foils checked.

The raw scores on the Raven Matrices and vocabulary checklist measure were separately standardized and then added together to form a verbal/non-verbal cognitive ability index. Because the correlation between this verbal/non-verbal index and the WAIS–R prorated IQ score was very high ($r = .707$), scores on these two derived measures were in turn used to create a composite cognitive ability measure. Scores on the WAIS–R prorated IQ score and Raven Matrices with vocabulary measures were separately standardized and then added together. It is this cognitive ability composite that is reported throughout the paper.[4]

Actively open-minded thinking questionnaire

Participants completed a questionnaire consisting of a number of subscales assessing styles of epistemic regulation. The response format for each item in the questionnaire was agree strongly (scored as 6), agree moderately (5), agree slightly (4), disagree slightly (3), disagree moderately (2), disagree strongly (1). The item from the subscales were randomly intermixed in with each other and with other scales not part of the present investigation. Most of the subscales are described in more detail in Sá *et al.* (1999) and Stanovich and West (1997).

Because the eight subscales on the actively open-minded thinking questionnaire displayed moderate intercorrelations, a composite actively open-minded thinking (AOT) score was formed. First the total scores on each of the subscales were standardized. Then the standard scores on the flexible thinking, openness-ideas, and openness-values subscales were summed. From this sum was subtracted the sum of the standard scores on the absolutism, dogmatism, categorical thinking, belief identification, and need for closure subscales (the creation of a composite score using the factor score from the first factor produced results virtually identical to those from the unit-weighted sum of standard scores). Thus, high scores on the AOT composite indicate openness to belief change and cognitive flexibility; whereas low scores indicate cognitive rigidity and resistance to belief change.

[4] We also employed other cognitive ability composite score variations in our analyses. Most notably, we derived an index of fluid intelligence and crystallized intelligence. The raw scores on the Block Design subtest of the WAIS–R and the Raven Matrices were separately standardized and then added together to form the index of fluid intelligence. The raw scores on the Vocabulary subtest of the WAIS–R and the Vocabulary checklist were separately standardized and then added together to form an index of crystallized intelligence. Correlations between these two indices with all primary variables were similar in magnitude. Furthermore, both these composites did not differ from the cognitive ability composite reported in this paper.

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Brief descriptions follow:

Flexible thinking scale. Items on the flexible thinking scale were devised by the authors and validated in a previous investigation (Stanovich & West, 1997). Items tap flexible thinking as a multifaceted construct encompassing the cultivation of reflectiveness rather than impulsivity ('If I think longer about a problem I will be more likely to solve it'), the seeking and processing of information that disconfirms one's belief ('People should always take into consideration evidence that goes against their beliefs'), and the willingness to change one's beliefs in the face of contradictory evidence (see Baron, 1993, 1994). There were 10 items on the scale.

Openness-ideas. The 8 items from the openness-ideas facet of the Revised NEO Personality Inventory (Costa & McCrae, 1992) were administered (e.g. 'I have a lot of intellectual curiosity', 'I find philosophical arguments boring'—the latter reverse scored).

Openness-values. The 8 items from the openness-values facet of the Revised NEO Personality Inventory were administered (e.g. 'I believe that laws and social policies should change to reflect the needs of a changing world'; 'I believe letting students hear controversial speakers can only confuse and mislead them'—the latter reverse scored).

Absolutism. This scale consisted of 9 items adapted from the Scale of Intellectual Development (SID) developed by Erwin (1981, 1983). The SID represents an attempt to develop a multiple choice scale to measure the early stages of Perry's (1970) model of intellectual development in young adulthood which are characterized by cognitive rigidity, by a belief that issues can be couched in either/or terms, that there is one right answer to every complex problem, and by reliance on authority for belief justification.

Dogmatism. The dogmatism subscale consisted of 9 items. Three were taken from a short-form field version (Troldahl & Powell, 1965) of Rokeach's (1960) dogmatism scale, two from Paulhus and Reid (1991), and four from the full Rokeach scale published in Robinson, Shaver, and Wrightsman (1991). Typical item: 'No one can talk me out of something I know is right.'

Categorical thinking. Three items from the categorical thinking subscale of Epstein and Meier's (1989) constructive thinking inventory were administered ('There are basically two kinds of people in this world, good and bad', 'I think there are many wrong ways, but only one right way, to almost anything', 'I tend to classify people as either for me or against me').

Belief identification. The belief identification scale developed by Sá *et al.* (1999) was inspired by a theoretical paper by Cederblom (1989) in which he argues for a potential thinking style centred around the extent to which people identify their beliefs with their concept of self (e.g. 'It makes me happy and proud when someone famous holds the same beliefs that I do'). A 9-item scale was distilled from Cederblom's (1989) discussion of this concept.

Need for closure. Twelve items taken from the Need for Closure Scale published in Kruglanski, Webster, and Klem (1993) were administered. Typical item: 'I dislike it when a person's statement could mean many different things.'

Procedure

Participants completed the tasks during a single session of 3–4 hours in which they also completed some other tasks not part of the present investigation. All were individually tested by the same experimenter. The order of tasks completed was: actively open-minded thinking questionnaire, opinion prediction task (part 1), knowledge prediction task (part 1 and 2), WAIS–R Vocabulary subtest, WAIS–R Block Design subtest, opinion prediction (part 2), Vocabulary checklist and Raven Matrices.

The sample size for the opinion prediction task was reduced from 123 to 117 due to several participants being multivariate outliers (having Mahalanobis distance metrics greater than 4.0 see Tabachnick & Fidell, 1983) or failing to understand the task. For similar reasons, the sample size for the knowledge task was reduced to 110.

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Results

Replication of the between-participants effects

Although not the focus of the present investigation, it is important to examine whether we have replicated the traditional consensus effect and traditional knowledge projection effect using the customary between-participants analysis. The results of a between-participants analysis of both effects can be seen in Fig. 1. Each point in Panel A of Fig. 1 represents one of the 29 opinion prediction items (one item—'I regard the right to speak my mind as very important'—was eliminated from Fig. 1 because it was endorsed by every participant). The horizontal coordinate of each point is set at the mean of the nonendorser estimate for that item and the vertical placement is set at the mean of the endorser group for that particular item. Points that lie directly on the diagonal line indicate identical percentage estimates given by the nonendorser group and the endorser group. As can be seen, all the points lie above the diagonal. In other words, for each of the items, the endorser group estimated higher endorsement than the nonendorser group, and in 22 cases this difference was statistically significant.

Panel B of Fig. 1 displays an identical between-participants analysis of the knowledge prediction task. The two groups in the knowledge prediction task were formed as a function of whether they did not know the answer (horizontal axis) or did know the answer (vertical axis). On 25 out of 30 of these knowledge questions, significantly higher estimates were given by the group who knew the answer as opposed to the group who did not know the answer. Thus on both of the projection tasks, a between-participants analysis demonstrates that participants are likely to project their mental contents on to others—their judgments of what opinions or knowledge others have is contaminated by their own opinion or knowledge.

Analyses of the Krueger overprojection parameter

The between-participants analyses shown above collapse across participants and thus provide no information concerning individual differences—a primary concern of the present research. Furthermore, as discussed, these analyses fail to reveal the consequences of projection in terms of predictive *accuracy* (see Dawes, 1989, 1990; Hoch, 1987; Krueger, 1998; Krueger & Zeiger, 1993). To address this issue, we conducted several within-participants analyses employing various parameters introduced in recent work on the false consensus effect. The first was an analysis of a parameter introduced by Krueger and Zeiger (1993). A parameter that can index over (or under) projection at the individual level that is relative to the actual accuracy achieved can be obtained by correlating each participant's own position across items (O; scored as 0/1; where own position becomes nonendorsement/endorsement in the opinion prediction task and not-know/know in the knowledge prediction task) with the difference between the predicted percentage (P) and the target percentage (T, the actual percentage of endorsement or knowers in the target population)—$r(O, P-T)$. The respective mean of $r(O, P-T)$ for the opinion prediction task and the knowledge prediction task was $-.065$ ($SD = .228$) and $-.038$ ($SD = .259$),

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respectively. These slightly negative indices are an indication that participants may not be overprojecting.

The Hoch (1987) parameters

In the Hoch (1987) analysis, predictive accuracy is indexed for each individual separately by correlating the actual target value for each item (T) with the participant's prediction of that target value (P). The average $r(T, P)$ index for participants in the opinion prediction and knowledge prediction task was found to be .501 (SD = .206) and .658 (SD = .124) respectively. The potential diagnosticity of own position, $r(T, O)$, in the opinion prediction and knowledge prediction task was found to be .510 (SD = .200) and .591 (SD = .128) respectively. The projection index, $r(P, O)$, averaged .470 (SD = .199) and .657 (SD = .122) in the opinion prediction and knowledge prediction task, respectively. The use of other diagnostic cues, indexed by $r(T, Z)$, averaged .295 (SD = .171) and .353 (SD = .169) in the opinion prediction and knowledge prediction task, respectively.

Thus, as a group, participants in the opinion prediction task perceived less consensus than there actually existed, i.e. $r(P, O)_{opinion} < r(T, O)_{opinion}$. Furthermore, converging with the previous analyses of the Krueger index, more projection in the opinion prediction task by participants would have actually facilitated their predictive accuracy, i.e. $r(T, O)_{opinion} > r(T, P)_{opinion}$. The opposite was true in the knowledge prediction task. Participants there perceived more consensus than actually existed, i.e. $r(P, O)_{knowledge} > r(T, O)_{knowledge}$; and more projection in this task would not have facilitated predictive accuracy, i.e. $r(T, O)_{knowledge} < r(T, P)_{knowledge}$.

Predictive accuracy, domain generality, and patterns of individual differences

The correlation matrix presented in Table 2 displays relationships that are relevant to the three main questions addressed by this investigation. First, on the issue of the correlates of predictive accuracy, we see that the normative cautions issued by Hoch (1987), Krueger and Zeiger (1993), and Dawes (1989) are justified for both tasks—there are no indications that projection of one's own opinion has deleterious effects on accuracy. Krueger and Zeiger's (1993) index of overprojection failed to correlate with predictive accuracy, $r(T, P)$, for either task (.145 and −.077, respectively). The Hoch projection index, $r(P, O)$, did not correlate with accuracy in the knowledge prediction task (.045) and it displayed quite a strong *positive* correlation with predictive accuracy in the opinion prediction task (.591). In that task, individuals more prone to project their own opinion were more accurate in predicting the opinion of others. Finally, regarding predictive accuracy, in both tasks the tendency to use other cues in addition to own opinion (indexed by the $r(T, Z)$ parameter) was strongly related to predictive accuracy (correlations of .772 and .700 for opinion prediction and knowledge prediction tasks, respectively).

Domain generality of effects across the two types of tasks depended strikingly on the particular parameter. Predictive accuracy across the two tasks displayed a significant correlation (.408) at the .001 level. Likewise, the tendency to use other

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Table 2. Intercorrelations among the primary variables

Variable	1	2	3	4	5	6	7	8	9	10	11
Opinion prediction indices											
1. r(T, P)											
2. r(P, O)	.591***										
3. r(O, P − T), Krueger	.145	.414***									
4. r(T, O)	.472***	.411***	−.370***								
5. r(T, Z)	.772***	.136	.216*	−.066							
Knowledge prediction indices											
6. r(T, P)	.408***	.290**	.177	.182	.315***						
7. r(P, O)	−.049	.084	.026	.065	−.117	.045					
8. r(O, P − T), Krueger	−.066	.000	.107	.029	−.042	−.077	.463***				
9. r(T, O)	.094	.011	.039	.051	.057	.346***	.224*	−.489***			
10. r(T, Z)	.340***	.238*	.119	.121	.295**	.700***	−.338***	.134	−.365***		
Cognitive ability											
11. Cognitive ability composite	.295**	.158	.064	.205*	.247**	.395***	−.129	.069	−.121	.495***	
Styles of epistemic regulation											
12. AOT composite	.408***	.225*	−.003	.358***	.251**	.332***	−.129	.074	−.058	.360***	.363***

$*p < .05$; $**p < .01$; $***p < .001$; all two-tailed.

Note. r(T, P) = predictive accuracy index, correlation between target and predictions; r(P, O) = projection index, correlation between predictions and own position (scored 0/1); r(O, P − T), Krueger = overprojection index, own position correlated with the difference between prediction and target; r(T, O) = potential diagnosticity of own position, own position correlated with the target; r(T, Z) = use of other diagnostic cues, correlation between target and other cues used by participant, Z, estimated from residuals when P is regressed on O; AOT = composite actively open-minded thinking scale.

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diagnostic cues to increase predictive accuracy (r(T, Z)) displayed a significant correlation across the two tasks (.295, $p < .01$). However, the tendency to project own position (whether that be an opinion, or knowledge) as measured by the Hoch r(P, O) parameter did not correlate across the two tasks ($r = .084$). Similarly, the Krueger overprojection index (r(O, P-T)) did not associate across the two tasks ($r = .107$).

Parallel trends were observed when these parameters were correlated with the individual difference variables—cognitive ability and the actively open-minded thinking (AOT) composite score. That is, the parameters that displayed domain generality tended to correlate with the individual difference variables and those parameters displaying domain specificity tended not to correlate with the individual difference variables. Specifically, cognitive ability correlated with predictive accuracy in both the opinion prediction and knowledge prediction tasks (.295 and .395, respectively). Similarly, the AOT composite displayed significant correlations with predictive accuracy in both the opinion prediction and knowledge prediction tasks (.408 and .332, respectively). Likewise, with the other parameter that displayed domain generality, r(T, Z)—cognitive ability displayed significant correlations with this parameter in both the opinion prediction and knowledge prediction tasks (.247 and .495, respectively), as did the AOT composite (.251 and .360, respectively).

As true in previous investigations employing various other reasoning and judgment tasks (see Sá *et al.*, 1999; Stanovich, 1999; Stanovich & West, 1998b), we found that styles of epistemic regulation accounted for unique variance in the performance criterion variables of these particular tasks. Table 3 displays the results of two separate hierarchical regression analyses. The criterion variable in the first hierarchical regression is predictive accuracy in the opinion prediction task. Entered first into the regression equation is the cognitive ability composite. As can be seen on that table, cognitive ability is a significant predictor of predictive accuracy. Entered into the regression equation as a second step is the AOT composite. The results show that the AOT composite accounts for additional variance in predictive accuracy in the opinion prediction task once all the variance in common with cognitive ability is partialled out. The criterion variable in the second hierarchical regression in Table 3 is predictive accuracy in the knowledge prediction task. Once again cognitive ability is entered first followed by the AOT composite. As can be seen on Table 3, the AOT composite also accounts for additional variance above and beyond what can be explained by reference to cognitive ability alone (albeit to a lesser degree than in the opinion prediction task). These converging results across investigations of reasoning and judgment competence using various tasks point to the importance of addressing intentional-level psychological dispositions related to styles of epistemic regulation.

In contrast to the relationships with predictive accuracy, the projection parameters displayed very weak associations with the individual differences variables. Cognitive ability failed to correlate significantly with the Hoch projection index (.158 and −.129) or the Krueger overprojection index (.064 and .069). The AOT composite score displayed a correlation at the .05 level with Hoch projection index (.225) but did not correlate with this index in the knowledge prediction task (−.129). The former correlation probably arose because r(T, O) happened to display a correlation

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Table 3. Hierarchical regression analyses predicting predictive accuracy

Step variable	R	R^2 change	*F* change	Partial *r*
Opinion prediction *r*(T, P)				
1. Cognitive ability	.295	.087	10.92***	
2. AOT	.437	.104	14.69***	.338
Knowledge prediction *r*(T, P)				
1. Cognitive ability	.395	.156	19.91***	
2. AOT	.441	.039	5.20*	.215

$^*p < .05$; $^{***}p < .001$.
Note. AOT = composite actively open-minded thinking scale.

of .358 with AOT composite. Finally, the Krueger overprojection index failed to correlate with the AOT composite on either task (−.003 and .074).

Differences in projection and predictive accuracy across the two tasks

One puzzling result indicated in Table 2 was that projection, as measured by the *r*(P, O) index, appeared to have different consequences across the two tasks. Whereas projection was associated with accuracy in the opinion prediction task, projection failed to correlate with predictive accuracy in the knowledge prediction task. At first glance, the latter finding may seem a bit puzzling in light of the fact that the potential diagnosticity of own position in the knowledge prediction task, *r*(T, O), was positively correlated with predictive accuracy ($r = .346$). Thus one might have expected that projection of a potentially diagnostic cue would facilitate predictive accuracy. The explanation of this apparent paradox resides in the negative correlation between *r*(T, O) (the potential diagnosticity of own knowledge) and the use of other diagnostic cues, *r*(T, Z). These two potential cues were negatively correlated with each other ($r = -.365$, $p < .001$). Although *r*(T, O) was positively correlated with predictive accuracy ($r = .346$), the (T, Z) index was more strongly correlated with predictive accuracy ($r = .700$). Thus participants who made increasing use of their own knowledge by projecting it in their judgments did so at the expense (as indicated by the negative sign on the correlation) of a more potent predictor of accuracy.

The negative relationship between *r*(T, O) and *r*(T, Z) observed in the knowledge prediction task did not occur in the opinion prediction task. Why might the trade offs between these two cues be different across the two tasks? The negative correlation that arises between potential diagnosticity of own knowledge, *r*(T, O), and use of other diagnostic cues, *r*(T, Z), can be explained by the factor of knowledgeability —which is an issue only in the knowledge prediction task. The perception of respective knowledgeability among the reference group and the associated difficulty level of the knowledge question creates a cue not available in the prediction of opinions—knowledge held by the group can be calibrated from one's own point on the knowledgeability continuum because there is a common factor running through the knowledge items in a way that is not true for mere opinions. By way of example,

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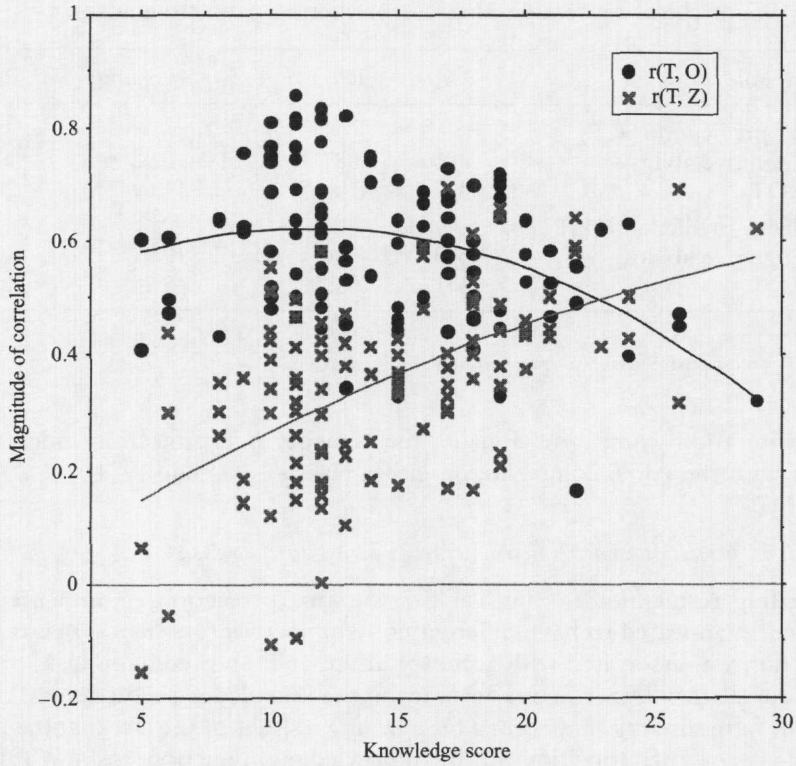

Figure 2. Simultaneous plot of $r(T, O)$ and $r(T, Z)$ as a function of knowledge score.

take a participant who knows herself to be extremely knowledgeable in reference to her peer group. When presented with a difficult knowledge question, such an individual may take her struggle for the correct answer as a diagnostic indicator of how the reference group will perform on that item. In this particular case, she may decide to estimate a low percentage of correct responders. Thus her estimation is sensitive to her perception of her respective knowledgeability among her reference group and the associated difficulty level of the knowledge question. Note that a simple projection strategy would not serve such an individual well. In short, the subject has a fixed reference point across all of the items (information on their own knowledge level) and the difficulty of the question provides a clue to how to adjust from this fixed point. This sort of cue is simply not available in the prediction of opinions. There is no fixed point of reference across the items. Opinions cannot be rank-ordered on any useful dimension as readily as the ability to rank knowledge questions on a dimension of difficulty level.

To generate empirical evidence for this conjecture, we calculated a knowledge score by summing the number of knowledge questions that each participant answered correctly. The mean of this knowledge score was found to be 14.8 (SD = 4.8). Figure 2 simultaneously plots $r(T, O)$ and $r(T, Z)$ as a function of this

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knowledge score. Note that each participant is represented in Fig. 2 as a pair of vertically aligned data points. One data point represents a participant's $r(\mathrm{T}, \mathrm{O})$ value and the other represents the participant's $r(\mathrm{T}, \mathrm{Z})$ value. A quadratic regression curve is fitted separately for the $r(\mathrm{T}, \mathrm{O})$ and $r(\mathrm{T}, \mathrm{Z})$ values. As can be seen in Fig. 2, the nature of the relationship between knowledge and $r(\mathrm{T}, \mathrm{O})$ and knowledge and $r(\mathrm{T}, \mathrm{Z})$ is very different. Whereas the utility of other diagnostic cues, $r(\mathrm{T}, \mathrm{Z})$, continually increases as the knowledge score increases, the potential diagnosticity of own knowledge, $r(\mathrm{T}, \mathrm{O})$, displays a steady decrease beginning at a knowledge score of about 15 (near the sample mean of this variable). In other words, the more knowledgeable participants were, the less diagnostic their own knowledge became (i.e. their own position cue, know/not-know), and at the same time, other diagnostic cues continued to increase in diagnosticity. This is precisely the data pattern that would be expected given our above conjecture for a factor of knowledgeability.

Discussion

The results of this investigation clearly demonstrated that participants' judgments of the contents of another person's mind—whether it be an opinion or actual knowledge—were influenced by the contents of their own mind. Using between-group analyses, we replicated the traditional 'false' consensus effect in an opinion prediction task and its analogue in a knowledge prediction task. These judgments could be interpreted as resulting from a type of processing bias previously termed mental contamination (see Wilson & Brekke, 1994). However, within-participants examination of individual differences in projection tendencies and their relation to predictive accuracy indicated that the mental contamination across the two tasks displayed considerable domain specificity and its implications for predictive accuracy were quite different.

First, projection facilitated judgments of other peoples' opinions, results that are consistent with recent work on the false consensus effect (e.g. Hoch, 1987; Krueger, 1998). In contrast, mental contamination due to projection showed no evidence of facilitating accuracy in making judgments of other peoples' knowledge. Projection ($r(\mathrm{P}, \mathrm{O})$) did not correlate with accuracy on the knowledge prediction task despite the significant diagnosticity of one's own knowledge as a cue ($r(\mathrm{T}, \mathrm{O}) = .591$), and despite the significant positive correlation of .346 between the potential diagnosticity of own knowledge ($r(\mathrm{T}, \mathrm{O})$) and predictive accuracy ($r(\mathrm{T}, \mathrm{P})$). However, there existed a much stronger correlation (.700) between use of other diagnostic cues ($r(\mathrm{T}, \mathrm{Z})$) and predictive accuracy ($r(\mathrm{T}, \mathrm{P})$). Furthermore, the use of other diagnostic cues was negatively correlated with the own knowledge cue ($-.365$). Thus, participants who were mentally contaminated were contaminated by a diagnostic cue (as in the opinion prediction task), but the utilization of this cue came at the cost of a more potent predictor (viz. the use of other diagnostic cues).

We argue that a significant portion of the predictive accuracy attributed to the use of other diagnostic cues arises from participants' ability to calibrate their judgments in reference to their perceived knowledgeability among their reference group. Unlike the opinion prediction task, each item on the knowledge prediction task is conducive to some assignment of associated difficulty level relative to the participant's *own* level

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of knowledge which is *known* to the participant—a cue missing in the opinion prediction situation. The utility of making use of this diagnostic cue should be positively correlated with knowledgeability. This follows because it is difficult to track the difficulty level of knowledge questions if you yourself do not know the answer to a large set of those items. You cannot rank order the difficulty of the items you have never learned. Thus, people with little knowledge lack the ability to use this cue. On the other hand, being highly knowledgeable enables you to track more accurately the difficulty level of the knowledge questions thereby increasing the utility of this cue. We observed a significant correlation between the knowledge score and the use of other diagnostic cues ($r = .523$; see Fig. 2).[5]

Our argument that projection in a knowledge prediction task is done at the expense of other diagnostic cues suggests a further theoretical corollary. It is the hypothesis that when own mental contents is a diagnostic cue, projection may facilitate judgments of other people's knowledge if other diagnostic cues do not correlate negatively with own mental contents (or if other diagnostic cues cannot be utilized, or if none exist, or if they are inaccessible). Mitchell, Robinson, Isaacs, and Nye (1996) have illustrated an instance where the latter scenario seems to be at work. Mitchell *et al.* (1996) argued that preschool children fail theory of mind (ToM) tasks because their judgments of other peoples' beliefs is mentally contaminated by the child's knowledge of reality (a reality that is more salient for the preschooler than are the appropriate folk psychological constructs). Although the mental contamination preschool children exhibit in their judgments of mind will lead them to fail the experimenter's ToM tasks, for the most part it will facilitate their accuracy in judgments of other people's beliefs. As Mitchell *et al.* argue 'since simple factual beliefs would normally be true, a short cut to judging belief is to report reality' (pp. 16–17). Thus for the computationally limited preschooler, invoking another diagnostic cuing system (in this case the use of a mature folk psychology) is computationally too taxing. By resorting to a less demanding strategy of projecting one's own knowledge of reality, preschoolers are more often than not able to judge other people's beliefs accurately.

Our results yielded no support for the view that mental contamination is a domain general tendency. A near zero correlation ($r = .084$) between the two projection indices suggests strong domain specificity.[6] There was no relationship between the tendency to project own opinion when judging other peoples' opinions and the tendency to project own knowledge when judging other peoples' knowledge. Additionally, the projection indices of both mental content prediction tasks (with a minor exception) failed to correlate with either the cognitive ability or the actively open-minded thinking measure.

The correlation pattern observed across these two tasks is accommodated nicely by two-process models of cognition. The lack of domain generality and the failure

[5] In addition, we found that this correlation was not simply a consequence of general cognitive ability underlying both knowledgeability and use of other diagnostic cues. The partial correlation between the knowledge score and use of other diagnostic cues once cognitive ability and AOT scores are statistically controlled remained significant (partial $r = .366$, $p < .001$).

[6] The correlation between the two standardized beta weights for own mental contents across the two tasks (beta weight for O when P is regressed on O and T) a measure of mental contamination that controls for projection related to predictive accuracy, also displayed a near zero correlation ($r = .042$).

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to correlate with cognitive ability is consistent with the suggestion that heuristic processes underlie the projection mechanism in these two tasks. Our interpretation of projection as an automatic heuristic process is also consistent with Krueger's (1998; see also Krueger & Zeiger, 1993) review of the false consensus literature in which he argued that projection is carried out with lack of awareness, efficiency, lack of controllability, and lack of intention—all defining characteristics of an automatic process.

Conversely, use of other cues to enhance predictive accuracy displays the characteristics of capacity-demanding analytic processes (see Evans & Over, 1996; Reber, 1993; Stanovich, 1999). For example, whereas the projection indices did not correlate with one another across these two tasks, the ability to identify and make good use of other diagnostic cues (the $r(\mathrm{T}, \mathrm{Z})$ indices) *was* correlated across these two tasks ($r = .295$, $p < .01$). As a result, the predictive accuracy index in the opinion prediction task did attain a significant correlation with the predictive accuracy index in the knowledge prediction task ($r = .408$, $p < .001$). Additionally, whereas projection—a function of heuristic processes—displayed few correlations with individual difference variables, participants who were able to identify and make appropriate use of other diagnostic cues in both tasks—a function of analytic processes—were higher in cognitive ability and styles of epistemic regulation lending themselves to actively open-minded thinking. As a result, predictive accuracy also correlated with these individual difference variables.[7]

In summary, our results indicated that under conditions where other diagnostic cues are either unavailable or do not correlate negatively with own mental contents (the opinion prediction task), projection is a heuristic process that in fact contributes to predictive accuracy as Dawes (1989), Hoch (1987), and others (see Krueger & Zeiger, 1993) have argued. In contrast, when other diagnostic cues are available (and particularly when they correlate negatively with the diagnosticity of own information—as in the knowledge prediction task) controlled use of other cues must override the heuristic projection process. Thus, performance on these tasks seems to be well captured by two-process models of cognition which hypothesize the operation of parallel processes of analytic and heuristic processing (Evans, 1984, 1989; Epstein, 1994; Sloman, 1996). Heuristic systems are viewed as automatic, largely unconscious, and relatively undemanding of computational capacity. Analytic processes have been associated with rule-based processing that is controlled and capacity-demanding. Importantly, the two classes of process have different relationships with general intelligence. Following Reber (1993), it is usually assumed that analytic processing is much more strongly associated with cognitive ability measures such as intelligence tests (for evidence on this issue, see McGeorge *et al.*, 1997; Reber *et al.*, 1991). The results reported here appear to support such a parsing of the cues available in both of these mental content prediction paradigms. Projection of one's own mental contents appears to have the characteristics of heuristic processing whereas the use of other cues appears to engage analytic intelligence —particularly in situations like that in the knowledge projection task[8] where projection must be overridden by the use of other cues.

[7] In fact, cognitive ability did not correlate with predictive accuracy once $r(\mathrm{T}, \mathrm{Z})$ has been partialled out.
[8] On the role of system overrides in two-process models, see Stanovich (1999).

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