The ease and extent of recursive mindreading, across implicit and explicit tasks

Abstract

Recursive mindreading is the ability to embed mental representations inside other mental representations e.g. to hold beliefs about beliefs about beliefs. An advanced ability to entertain recursively embedded mental states is consistent with evolutionary perspectives that emphasise the importance of sociality and social cognition in human evolution: high levels of recursive mindreading are argued to be involved in several distinctive human behaviours and institutions, such as communication, religion, and story-telling. However, despite a wealth of research on first-level mindreading under the term Theory of Mind, the human ability for recursive mindreading is relatively understudied, and existing research on the topic has significant methodological flaws. Here we show experimentally that human recursive mindreading abilities are far more advanced than has previously been shown. Specifically, we show that humans are able to mindread to at least seven levels of embedding, both explicitly, through linguistic description, and implicitly, through observing social interactions. However, our data suggest that mindreading may be easier when stimuli are presented implicitly rather than explicitly. We argue that advanced mindreading abilities are to be expected in an extremely social species such as our own, where the ability to reason about others' mental states is an essential, ubiquitous and adaptive component of everyday life.

Keywords: mindreading; mentalizing; theory of mind; metarepresentation; intentionality; evolution; social cognition

"Humans have the ability to represent representations… This meta-representational ability is as distinctive of humans, and as important in understanding their behaviour, as is echolocation for bats" (Sperber, 1997, p.69)

Introduction

Mindreading is the ability to mentally represent others' mental representations. It is also known as mental metarepresentation, or theory of mind. Recursive mindreading is the ability to embed further levels of mental representation inside existing mental representations (e.g. I think$_0$ that you believe$_1$ that he thinks$_2$ that she wants$_3$... and so on; subscripts count the number of metarepresentations[1]). An intuitive and commonly held view is that high-level recursive mindreading (i.e. beyond first or second level) is cognitively demanding, and perhaps beyond normal human abilities (e.g. Gómez, 1994; Clark, 1996). Yet theoretical explanations of many important human behaviours and institutions, such as communication, religion, story-telling, and culture itself either argue or assume that humans can and do process high levels of recursive mindreading routinely and without difficulty (Sperber, 2000a; Dunbar, 2003; 2008; Tomasello, 2008). Furthermore, our natural ecology is a social one, in which both collaboration and competition are everyday activities (Humphrey, 1976; Byrne & Whiten, 1989; Dunbar, 2003). In such an environment, the ability to monitor and manage one's social environment, by reasoning about the motives and intentions of others, keeping track of others' relationships, deciding who to trust, and so on, is of critical importance. From this perspective, we should expect humans to be able to process mental (meta)representations with relative ease, at least when those representations are encountered within this social ecology.

There is a large literature on various aspects of first-level mindreading (e.g. the ability to reason about the mental state of another: I think$_0$ that you believe$_1$ some proposition) This includes, most prominently, its development in children (Wellman et al., 2003; Baillargeon et al., 2010), its role in some social cognitive disorders (Baron-Cohen, 1995; Chevallier et al., 2012), and its presence or absence in non-human primates (Premack & Woodruff, 1978; Call & Tomasello, 2008). In contrast, there is far less research dealing specifically with recursive mindreading, despite its importance for human social life. The handful of studies in adults that do exist report a prominent drop in performance after four levels of recursive mindreading (Kinderman et al., 1998; Stiller & Dunbar, 2007; Lyons et al., 2010). There is also a small literature on second- and third-level tasks in children's development,

[1] There is inconsistency in the mindreading literature regarding how to count the levels. Some studies include the focal individual's perspective; others exclude it. This is the difference between counting the number of representations (I think$_1$ that Mary thinks$_2$...) or only the number of metarepresentations (I think$_0$ that Mary thinks$_1$...). Most adult studies use the former practice, whereas the developmental literature uses the latter. We follow this latter practice in this paper.

which finds that the ability to perform these higher-level tasks emerges later in development than competence in first-level tasks (see Miller, 2009 for a review).

However, previous research on high-order recursive mindreading may have significantly underestimated the extent of human recursive mindreading abilities, for at least two reasons. First, the stimuli used in previous studies have a number of shortcomings serious enough to raise doubts about their validity. We detail these issues in the next section. Second, previous studies tested recursive mindreading ability only *explicitly*, by presenting stimuli either as text to be read, or narration to be heard, and by testing understanding with direct questions, and not *implicitly,* by presenting stimuli as social events to be observed, and testing understanding by measuring reactions to those events. It may be the case, especially given the ecological perspective outlined above, that human mindreading abilities are fully expressed only when they are employed within social contexts i.e. when encountered implicitly (as opposed to being encountered as explicit, disembodied descriptions of those same contexts). This possibility is supported by findings in the developmental literature which shows that children pass implicit first-level mindreading tasks (false belief tasks) far earlier than they do equivalent explicit tasks: around the first birthday vs. around the fourth birthday (see Baillargeon et al., 2010 for a review of implicit false-belief tasks). Precisely what causes this dramatic difference is an unresolved issue in Developmental Psychology, but whatever the explanation, these results show that the mode of presentation can make a dramatic difference to performance, at least in children. Based on this finding, we might expect that adult performance on recursive mindreading tasks could also be facilitated by implicit presentation.

In sum, recursive mindreading plays an important role in explanations of many major human behaviours, yet there are reasons to think that we may not currently know or appreciate the full extent of this ability in adult humans. In this paper, we present a new study of recursive mindreading, which has two major advances on previous research. First, we use new stimuli designed to avoid the various methodological issues we have identified in previous studies (detailed below). Second, we use a 2x2 design of implicitly and explicitly presented stories, crossed with implicitly and explicitly presented questions. As such, the key novelty here is the use of implicit stimuli, which have not previously been used in the study of recursive mindreading in adults. We expected that, at least in conditions featuring implicit presentation, participants would succeed at recursive mindreading tasks at levels higher than those reported in previous studies. Correspondingly, our design includes questions of up to seven levels of mental metarepresentation, three levels higher than the typical level of successful performance in previous tasks (e.g. Kinderman et al., 1998; Stiller & Dunbar, 2007; Lyons et al., 2010).

Problems with previous research

Previous studies of recursive mindreading ability used versions of the Imposing Memory Task (IMT)[2] (e.g. Kinderman et al., 1998; Stiller & Dunbar, 2007; Lyons et al., 2010). The IMT has also been widely used as a measure of mindreading ability in studies designed to identify brain regions involved in mindreading (e.g. Powell et al., 2010; Lewis et al., 2011), in studies designed to investigate the relationship between mindreading and various cognitive disorders (e.g. Frith & Corcoran, 1996; Kerr et al., 2003), and in studies designed to investigate the relationship between mindreading ability and other aspects of social psychology, in both adults and children (e.g. Liddle & Nettle, 2006; Henzi et al., 2007; Paal & Bereczkei, 2007; Nettle & Liddle, 2008; Sylwester et al., 2012). The IMT involves stories which are read aloud to participants, followed by a series of true-or-false or forced-choice mentalising questions, designed to test participants' understanding of the levels of recursive mindreading involved. Control questions are designed to test participants' ability to remember details of the stories that are unrelated to mental states, but which contain a matched number of elements to be remembered. We analysed the stimuli used in the IMT[3] and identified five main problems that, collectively, are significant enough to cast doubt on the conclusions drawn in these studies regarding the extent of recursive mindreading ability. We describe these issues in the following paragraphs. A full breakdown of which of these criticisms apply to which questions in the IMT is provided as *Supplementary Information*.

Broken conceptual chains. In some cases, mental questions are constructed in a way that allowed them to be processed in 'chunks', rather than as a single metarepresentational unit. For example, the following sentence is intended to test fourth level mindreading: 'Simon imagined$_1$ that Betty wanted$_2$ to marry Edward but that Edward really wanted$_3$ to marry Susan, whom Jim would like$_4$ to have married' (here and elsewhere in this paragraph, we have omitted the participant's own mental state, which, if we had included it, would have had the subscript 0 (i.e. 'The participant believes$_0$ that Simon imagined$_1$…')). However, this sentence does not contain one continuous chain of mental representations. Rather, it consists of three statements, joined by logical relationships: (i) Simon imagined$_1$ that Betty wanted$_2$ to marry Edward; (ii) Simon imagined$_1$ that Edward really wanted$_2$ to marry Susan; and (iii) Simon imagined$_1$ that Jim would like$_1$ to have married Susan. Consequently, constructions of this sort do not test 4th

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[2] Although based on the IMT, some of the later studies do not use the name IMT. Here, we use IMT to refer to all studies based on the same general idea, and set of questions used.

[3] With one exception, none of the currently published studies that we are aware of provide a complete list of the specific questions used. The exception (Liddle & Nettle, 2006) used a version modified for children. We therefore analysed the complete set of IMT questions sent to us by R. Dunbar. This set of questions is an updated version of the materials used in the earliest IMT studies, and forms the basis for the materials used in later studies. As such, the items we analysed are representative of the stimuli used in this literature.

level mindreading; they test the conjunction of multiple cases of 2nd level mindreading. 13 of 50 mental questions in the IMT are constructed like this.

Simple substitution. Some stimuli are constructed in such a way that the entire sentence did not need to be processed in order to be answered correctly. An example is the forced choice between 'The girl whose car Simon works on practices dance with the person who is a loan officer in Edward's bank' and 'The girl whose car Simon works on practices dance with the person who is a computer consultant in Edward's bank' (from Rutherford, 2004). The only difference here is between 'loan officer' and 'computer consultant'. In many cases, one of these alternatives simply did not appear in the story at all. As such, the question can be answered by simply spotting the unfamiliar item: the full sentences, and the complex propositions they convey, do not need to be understood. This occurs in 6 of 50 control questions, and 1 of 50 mental questions.

Impossible choices. Some questions in the IMT cannot be answered based on the information included in the story, or based on reasonable inference from the story. For example, in one story we are told that: Henry gave Sam faulty information; that Henry is a prankster, and Sam suspects him of playing a trick; and that their colleague Pete does not think Henry was trying to trick Sam. Crucially, however, Henry's actual motivations (rather than just Sam's suspicions about them) are never mentioned, and cannot be reasonably inferred. Nevertheless, one true/false question was the statement 'Henry wanted to play a trick'. 7 of 50 mental questions and 2 of 50 control questions were impossible to answer in this way.

Syntactic complexity. The mentalising questions in the IMT are more syntactically recursive than the corresponding control questions. To measure this, we counted the number of embedded clauses in each of the questions (e.g. subordinate clauses such as "Susan wants to marry Edward" in the sentence "Jim thinks that Susan wants to marry Edward"). We found that the average number of embedded clauses was significantly higher in the mentalising questions than the control questions (Median level of embedding for control questions: 0; median for mental questions: 2; Mann-Whitney U Test, $p<.001$). This difference in syntactic complexity is not an issue for studies that use control questions only as a way to test participants' comprehension of the stories. However it is an issue if these controls are used as an experimental contrast with mental questions, as some IMT studies have done. For instance, neuroimaging studies use the control questions as a baseline task (e.g. Powell et al., 2010; Lewis et al., 2011). Consequently, it is possible that any differences in the brain regions associated with the two conditions may be due to the additional syntactic demands of the mental questions, rather than to mindreading specifically.

Inappropriate control questions. Finally, the control questions used in the IMT are arguably not appropriate controls in the first place, since they do not involve conceptual embedding. Recursion is the repetition of

a given feature, with each repetition embedded inside a previous instance of that feature (Karlsson, 2009). In a linguistic context, this would involve the embedding of a phrase within a similar phrase, for example:

[NP The book [PP on [NP the desk [PP in [NP the corner [PP of [NP the room]]]]]]]

This sentence involves a noun phrase (NP) 'the room' embedded within a prepositional phrase (PP) 'of the room' embedded within a larger NP 'the corner of the room', embedded within a larger PP, and so on. The syntax is recursive, and the concept itself is also recursive: each location is contained within another location. However, although syntactic recursion is often used to express conceptually recursive concepts, such as possession, recursive locations, or mental metarepresentations (e.g. "Jake thinks that I believe that Mary feels sad"), it is possible to express conceptual recursion without heavy syntactic recursion, through parataxis. For instance, the syntactically and conceptually recursive "Portia's dog Fido's ball" can also be expressed as "Portia has a dog. That dog is called Fido. Fido has a ball", which is conceptually but not syntactically recursive. As such, an appropriate control for recursive mindreading, which is conceptually recursive, would be to use control questions that are also conceptually recursive, while controlling for syntactic recursion across both types of question. However, control questions in the IMT do not contain the same level of syntactic recursion as mental questions (see 'Syntactic complexity', above). Mental questions also do not use recursive concepts in a controlled manner (see 'Broken conceptual chains', above). Instead, the mental questions in the IMT are more recursive than the control questions, both syntactically and conceptually.

Summary. Although there have been consistent findings with the IMT, pointing perhaps to its internal consistency, when taken as a whole the problems discussed above cast some doubt on its validity as a measure of recursive mindreading ability. Partly in light of this, and partly because we wished to use implicit as well as explicit tasks (as detailed above, the IMT uses explicit questions only), we developed new stimuli for our study.

The current study

Our new study was designed to address the following questions: (i) Does the step-change in performance after four levels of metarepresentation reported in previous studies still occur with different stimuli, which avoid the issues identified above?; (ii) If not, does performance decline gradually, or not at all?; and (iii) Is any effect specific to implicit mindreading tasks, or does it generalize to non-mindreading tasks and/or explicit tasks, which have less ecological validity than implicit tasks?

Methods

Participants. We recruited 66 participants (41F, 25M; average age 22y 10m). All participants were recruited from the student population of the University of Edinburgh, through the University Careers Service Student and Graduate Employment online database, and paid £7 for their participation. Participants were screened to ensure that they (1) were native English speakers, and (2) did not know any of the actors in the stories.

Materials. We wrote four original stories, each of which had a plot involving seven levels of recursively-embedded mental representation, and seven levels of a non-mental recursive concept, such as possession. The stories were written in two different formats: as scripts, to be acted; and as a narrative, to be read by a single story-teller. All details of plot, character, and so on were identical in both formats; only the manner of presentation differed. The scripts were then performed by actors (implicit story presentation) and filmed; the narrative was read out by a single story-teller and filmed (explicit story presentation). We also created, for each of the levels of mental and non-mental recursion, two scenes to follow the main story. One of these scenes was consistent with the relevant mental / non-mental aspect of the story, the other not. Again, these additional scenes were filmed both as scripts performed by actors (implicit test question presentation), and as narratives read by a single story-teller (explicit test question presentation). This gave a total of 14 test questions for each story (7 levels of recursion, each in mental and control conditions).

These stimuli were designed to avoid each of the problems identified in the previous section. First, we did not use any broken conceptual chains. Second, we took a number of steps to ensure that simple substitution was not possible, despite minimal differences between correct and incorrect answers in our explicit stimuli (see below). Third, the only differences between correct and incorrect stimuli involved differences in mental state attribution (e.g. ‘wants’ vs. ‘doesn’t want’), rather than other aspects of the scenario (e.g. ‘loan officer’ vs. ‘computer consultant’), thus ensuring that there was no confound of syntactic complexity. Fourth, ,we ensured that there were no impossible choices. Fifth, we used control questions that had the same levels of conceptual and syntactic recursion as our experimental questions.

Collectively, these aspects of our stimuli ensured that the two options could only be differentiated if participants had correctly understood the embedded levels of recursive mindreading involved. In particular, non-mindreading strategies based on forms of simple substitutions should not succeed at better than chance levels, and in any case are not possible for implicit questions. More specifically, while the correct and incorrect choices in the explicit stimuli were very similar to one another, the differences they did have were precisely and only those that

involved recursive mindreading. For example, one 4th-level mental question involved the choice between 'Stephen knows that Elaine knows that Bernard feels she doesn't know him well enough to date' and 'Stephen doesn't know that Elaine knows that Bernard feels she doesn't know him well enough to date'. The only difference here is in the first intentional verb ('Stephen knows…' vs. 'Stephen doesn't know…'). This means that in order to answer the question correctly, participants must parse everything that follows this verb – which in itself involves interpreting a three levels of mental metarepresentation – and then determine whether this is something that Stephen knows or not (a fourth level mental metarepresentation). Similarly, if correct and incorrect stimuli were also different at other points in the construction (e.g. 'Stephen knows that Elaine knows that Bernard feels she doesn't know him well enough to date' and 'Stephen doesn't know that Elaine doesn't know that Bernard feels she doesn't know him well enough to date'), then participants need only parse what follows those differences (i.e. they need only know if Elaine does or doesn't know that Bernard feels she doesn't know him well enough to date), and nothing before that. In short, our stimuli were designed to ensure that participants had to parse and comprehend the whole scenario in order to perform at above chance levels.

One of our stories is provided in the *Appendix*, in both narrative and script forms, with a complete set of questions for each. The full set of stories are provided as *Supplementary Information*, and the videos themselves are available at *http://hdl.handle.net/10283/609*.

Design. Each participant viewed and was tested on all four stories, with manner of story presentation and test question presentation fully crossed within subjects (i.e. participants saw one story with implicit presentation of the story and implicit testing, one with explicit story presentation and implicit testing, and so on), in a fully counter-balanced design, such that each story appeared in each position (1st viewed, 2nd viewed, etc.) an equal number of times, and each story appeared before and after each other story an equal number of times.

Procedure. Participants were first presented with the story video. They were able to watch this as many times as they liked before proceeding to the questions, after which they could not watch the story again (this mimics, in a different modality, the procedure used in several previous IMT tasks, in which participants read stories on paper). The fourteen test questions for each story (7 mental, 7 control) were presented in random order. For each question, two video frames were shown on the screen simultaneously, presenting the two forced choice options for that question, with left/right presentation randomized. Participants were able to watch both videos as many times as they liked (again, this mimics procedures from previous research), until they wished to identify, by mouse click, the video which they thought was consistent with the story. After each selection, participants were asked to rate their

confidence, on a scale of 1 (lowest) to 10 (highest), that they had chosen the correct answer. After making a selection, participants were not able to return to that question.

Data analysis. Data for a single story from three participants could not be used due to computer error. We analysed three dependent variables: success (i.e. identifying the correct video) on test; the confidence ratings that participants attached to those responses; and the number of times that participants viewed each question video before answering (which may index whether participants found certain types of questions more difficult than others, and had re-watch them in order to answer). For the statistical analysis, multilevel models with random effects were employed: responses were fitted to a binomial distribution for the binary success DV, and a Poisson distribution for the confidence rating and number of additional video views DVs[4]. Analyses were conducted in the R programming environment (version 3.1.1, R Core Team, 2013) using the lme4 package (version 1.1-7; Bates et al., 2014). Lme4 was used at default settings, except for the usage of the `bobyqa'-optimizer and increasing the maximum iterations to 100,000. The theoretically-motivated factors Level of Question Complexity (1-7, indicating required level of metarepresentation), Condition (Mental or Control), Story Presentation (Implicit or Explicit) and Question Presentation (Implicit or Explicit) were included as fixed effects for all DVs. Additionally, we included Number of Additional Story Views (i.e. beyond the first, obligatory viewing of the story) as a predictor, in order to control for the effects this might have on performance. Following Barr et al. (2013) we used a maximum random effects model, and consequently included Subject (64 levels) and Story (4 levels) as random effects, with by-Subject and by-Story random intercepts and random slopes for Level, Question Type, Story Presentation and Question Presentation, which represented the most complex converging model. For further analyses, we reduced the random effects structure further, if the models did not converge. The validity of the mixed effects analyses were assessed by computing likelihood ratio tests comparing models containing effects with null models that contained the intercept and the random effect structure only (c.f. Mundry, 2011). Due to the nature of multilevel analysis, F-ratios will not be reported.

Results

Success rates. The model predicting success did significantly better than the null model ($\chi 2(15)=28.244$, $p=.02$), and showed slight underdispersion (dispersion parameter of 0.771). Overall success rates for all questions

[4] As confidence ratings were generally towards the upper end of the 1 to 10 scale, confidence measures were subtracted from 10, in order to avoid predictions outside the possible range. Note that this reverses the expected sign of the coefficient estimates in the models for confidence.

were well above the level expected under chance performance (intercept in log-odds space of 2.356, corresponding to odds of greater than 10:1 of answering correctly, i.e. answering around 90% of all questions correctly). Moreover, there was very little evidence of any effect of Level or Condition on success (Level: β=-0.037, SE=0.055, p=.494; Condition: β=0.092, SE=0.329, p=.779; see Figure 1), nor of any interaction between these two factors (β=-0.073, SE=0.066, p=.266).

[figure 1 about here]

There were two significant interactions between predictors of accuracy (Figure 2). First, there was an interaction between Condition and Story Presentation (β=0.727, SE=0.282, p=.01). Post-hoc tests using dummy-coded data and taking Control-Explicit Story as the baseline showed that only the Mental-Explicit combination (i.e. the combination investigated in the IMT) performed worse than baseline (Mental-Explicit: β=-0.366, SE=0.173, p=.034; Control-Implicit: β=-0.526, SE=0.391, p=.179; Mental-Implicit: β=-0.067, SE=0.398, p=.866).

Second, there was an interaction between Story Presentation and Question Presentation (β=0.885, SE=0.304, p<.001). Post-hoc tests revealed no difference between the two modes of question presentation for Explicitly-presented stories (β=0.089, SE=0.603, p=.883), but for Implicitly-presented stories performance was significantly worse if the questions were presented Explicitly (β=0.767, SE=0.364, p=.035). In other words, an implicit story followed by an explicit question was the most difficult combination of Story Presentation and Question Presentations. All other main effects and interactions were not significant. (p>.204).

Finally, additional views of the story videos lead to a significant improvement in success (significant effect of Number of Additional Story Views: β=0.457, SE=0.138, p <.001). While the inclusion of Number of Additional Story Views as a factor does improve model fit significantly ($\chi2(1)=11.312$, p<.001), a model lacking Number of Additional Story Views as a factor produced qualitatively similar results to those outlined above.

In summary, participants were able to successfully process recursive mental concepts even at high levels of recursion, and this was no more difficult than other, non-mental recursive concepts.

[figure 2 about here]

Judgements of confidence. For the confidence data the fitted model did significantly better than the null model ($\chi2(15)=275.87$, p<.001), and had a dispersion parameter of 1.356 suggesting overdispersion within the acceptable range. Further analysis of confidence ratings revealed several effects of our manipulations. There was a small but significant effect of Level (β=0.106, SE=0.022, p<.001; see Figure 3): participants' confidence dropped as the levels increased even though, as noted above, their actual level of accuracy remained high. There were also a number of significant two- and three-way interactions involving Level. Confidence ratings for Mental but not

Control questions decrease with level (main model reveals a significant Level x Condition interaction, β=0.058, SE=0.012, p<.001; post-hoc tests using multilevel models on subsets of the data show a significant effect of Level for Mental questions, β= 0.070, SE=0.0546, p=.009, but not for Control questions, β=0.045, SE=0.030, p=.134). This interaction is further modulated by both Story Presentation and Question Presentation (Level x Condition x Story Presentation interaction: β=0.076, SE=0.024, p=.001; Level x Condition x Question Presentation interaction: β=-0.136, SE=0.024, p<.001). Post-hoc tests on Control questions reveal no two-way interactions between Level and Story Presentation ((β=-0.016, SE=0.017, p=.325) or Level and Question Presentation (β=0.020, SE=0.016, p=.206): however, these two-way interactions are significant for Mental questions (Level x Story Presentation: β=0.082, SE=0.019, p<.001; Level x Question Presentation: β=-0.116, SE=0.018, p<.001): confidence on Mental questions decreases faster with increasing Level when the story is presented Implicitly, or when the questions are presented Explicitly. Finally, there was also a three-way interaction between Condition, Story Presentation and Question Presentation (β=0.358, SE=0.098, p<.001). Post-hoc tests using dummy-coded data and taking Explicit Story-Explicit Question as the baseline showed that for Control questions, participants had significantly lower confidence for the Implicit Story-Explicit Question combination (β=0.464, SE=0.164, p=.005), with Implicit Story-Implicit Question (β=0.104, SE=0.270, p=.700) and Explicit Story-Implicit Question (β=0.281, SE=0.201, p=.125) not significantly different from the Explicit Story-Explicit Question intercept (β=0.438, SE=0.146, p<.001); in contrast, for Mental questions, participants had *higher* confidence for the Implicit Story-Implicit Question combination than for Explicit Story-Explicit Question (β=-0.537, SE=0.179, p=.003; other comparisons n.s., p>.137).

Finally, while there was a tendency for participants' confidence rating to increase with Number of Additional Story Views, this effect was not significant (β=-0.086, SE=0.049, p=0.079). Furthermore, including this factor did not significantly improve model fit ($\chi 2(1)=2.253$, p=.133) over an equivalent model lacking this factor, and the simpler model yielded qualitatively similar results to those discussed above

[figure 3 about here]

Number of additional video views. The third dependent variable was the number of times each question video was viewed. The fitted model did significantly better than the null model ($\chi 2(15)=172.52$, p<.001) and had a dispersion parameter of 1.095, suggesting low overdispersion within the acceptable range.

This model revealed a small but significant effect of Level (β=0.169, SE=0.016, p<.001): participants' required additional views of the question videos as levels increased. There were also significant effects of Condition (β=-0.272, SE=0.075, p<.001: mental questions required fewer additional plays) and Question Presentation (β=-0.473, SE=0.086, p<.001: implicitly-presented questions required fewer additional plays), and various two-way

interactions involving Level, Condition, and Question Presentation. Ultimately these are best explained by considering the significant three-way interaction between Level, Question Presentation and Condition (β=-0.171, SE=0.054, p=.001; see Figure 4). Post-hoc tests on subsets of the data show that the number of times the question videos were viewed increased with Level for Explicit questions (there were strong effects of Level in Explicit-Control and Explicit-Mental conditions: Explicit-Control, β=0.207, SE=0.030, p<.001; Explicit-Mental, β=0.278, SE=0.038, p<.001) and for Implicit-Control questions (β=0.131, SE=0.057, p=0.022), but not for Implicit-Mental questions (β=0.056, SE=0.100, p=.577), which showed no significant increase in additional question viewings with increasing complexity.

[figure 4 about here]

There was also a significant interaction between Story Presentation and Question Presentation (β=-0.404, SE=0.121, p < .001). Follow-up analyses using dummy coded data with Explicit Story - Explicit Questions as the baseline revealed that, compared to this baseline, combinations of Implicit Story - Implicit Questions required significantly fewer views before answering (β=-0.539, SE=0.129, p < .001), as did Explicit Stories – Implicit Question combinations (β=-0.397, SE=0.122, p = .001). Implicit Story – Explicit Question combinations required more views than baseline before answering, albeit not significantly so (β=0.170, SE=0.113, p = .131).

Finally, while there was a tendency for participants' to require fewer views of the question videos if they had watched the stories more often, this effect was not significant (β=-0.042, SE=0.075, p=0.574). Furthermore, including this factor did not significantly improve model fit ($\chi 2(1)=0.306$, p=.580) over an equivalent model lacking this factor, and the simpler model yielded qualitatively similar results to those discussed above.

Discussion

Our study produced several results worthy of note, of which two are of particular importance.

First, performance on mindreading tasks was high throughout (see Figure 1). The design of our stimuli ensured that this level of performance could not be due to guesswork or any other strategy that did not involve recursive mindreading (see *Methods*). These findings run counter to the intuition that high level recursive mindreading tasks are cognitively demanding, and counter to results obtained in previous research that suggest that performance on mental questions decrease markedly after level 5. One way to understand this result is by analogy with our perceptual skills: a formal description of what is involved in, say, vision, is complex, but this does not mean that seeing is a cognitively demanding activity, beyond the ken of typical human abilities. Our results suggest that

the same may be true of recursive mindreading, even at high levels of recursion. Interestingly, the apparently mistaken intuition that high levels of recursive mindreading are particularly cognitively demanding extends even to the individuals involved: while actual performance remained high across all levels, confidence levels declined as level of embedding increased, for Mental questions but not Control questions (see Figure 3).

Second, we found that participants viewed the videos more often as the level of complexity increased – except for implicitly presented, mental questions i.e. except in those contexts that are most ecologically valid (see Figure 4). This tentatively suggests that recursive mindreading is especially easy when employed within its natural environment, and that it is otherwise no more or less easy than recursive tasks in general. As we emphasised in the Introduction, humans' natural ecology is social. Correspondingly, prominent accounts of the evolution of human cognition emphasise the importance of specifically social cognition, including mental state attribution (Tooby & Cosmides, 1992; Sterelny, 2003; Tomasello, 2014). Our results make sense from this ecological perspective: recursive mindreading is an essential, ubiquitous, and adaptive component of everyday life, and as such, we should expect that we are good at it. A natural extension of our study, which would increase the ecological validity, would be to limit the participants to single views of both the story and the question videos (rather than the multiple views that, following previous research, we allowed for in the current design).

These results are consistent with the picture emerging from the literature on adult first-level mindreading, which shows that mindreading may be less like thinking, and more like perception i.e. something that we do unconsciously, as part of the background cognition that manages much of our daily lives (Apperly, 2011). Several experiments have now shown that in implicit contexts, we track the beliefs of others automatically, as part of our intuitive monitoring of the world around us, and that like our perceptual experiences, these representations of others' mental states fade quickly if we do not focus on them (e.g. Kovács et al., 2010; Samson et al., 2010; van der Wel et al., 2014). Our results tentatively suggest that the same may be true of recursive mindreading. In particular, we found that although participants in general increased their number of views of the question videos as level increased, suggesting an increase in the level of difficulty, this was not true of implicit mental questions.

It is also instructive to compare our results with the developmental literature. First, note that the classic Sally-Anne false belief task uses an implicit story (acted out using dolls, albeit with explicit commentary attached), followed by an explicit question. Our results show that this implicit-explicit combination is the most challenging combination for adults in recursive mindreading tasks (see Figure 2). The exact reasons why this should be the case are a topic for future research, but whatever the reason, this finding raises the possibility that the classic false belief task involves the most cognitively demanding combination of story and question presentation possible. More

generally, our results suggest two possible lines of future research on the development of mindreading abilities: (i) the use of explicit-explicit and/or explicit-implicit methods, in order to make comparisons with the existing implicit-explicit and implicit-implicit approaches; and (ii) the investigation of higher-level, recursive mindreading abilities in children, using implicit-implicit methods. Implicit-implicit methods have dramatically re-shaped our understanding of the development of simple mindreading abilities, but this advance has not yet been extended to the development of recursive mindreading abilities.

These results differ somewhat from previous research on adult recursive mindreading, which found a prominent drop in performance after four levels of metarepresentation. We suggest two possible reasons for this. The ecological validity of our implicit tasks cannot fully explain this, since we also find high levels of performance on explicit tasks. A more likely explanation is the various methodological problems we have identified with the IMT, which previous studies used as a measure of mindreading ability (see *Problems with previous research*, above). These methodological problems raise the possibility that previous results may not accurately reflect human mindreading abilities, and their relationship to other aspects of social psychology, as accurately as possible. Further investigation into the exact reasons for the differences between our study and previous research may be warranted.

The broader implications of our findings are several. In particular, our results should reduce concerns that some theoretical explanations of many important human behaviours and institutions are implausible precisely because they invoke high level recursive mindreading abilities. For example, the most prominent theoretical accounts of human communication argue that it involves the expression, on the part of the speaker, of an intention that the audience recognises that the speaker has an intention to inform the audience – and that the audience must recognise these embedded intentions (Grice, 1969; Sperber, 2000b; Tomasello, 2008; Csibra, 2010). Several researchers have argued that, while theoretically cogent, this analysis is empirically implausible, precisely because it depends upon high levels of recursive mindreading, which are assumed to be cognitively demanding (e.g. Gómez, 1994; Clark, 1996; Glüer & Pagin, 2003; Breheny, 2006). Our results suggest that these concerns are likely unfounded: at least in the contexts we explored here, recursive mindreading poses no particular challenges for adult humans, even at high levels of embedding. The same point applies to numerous other activities that have been argued to depend upon recursive mindreading, such as language, story-telling, culture, and even consciousness (Sperber, 2000a, Dunbar, 2003; 2005; 2008; Corballis, 2011; Graziano, 2013).

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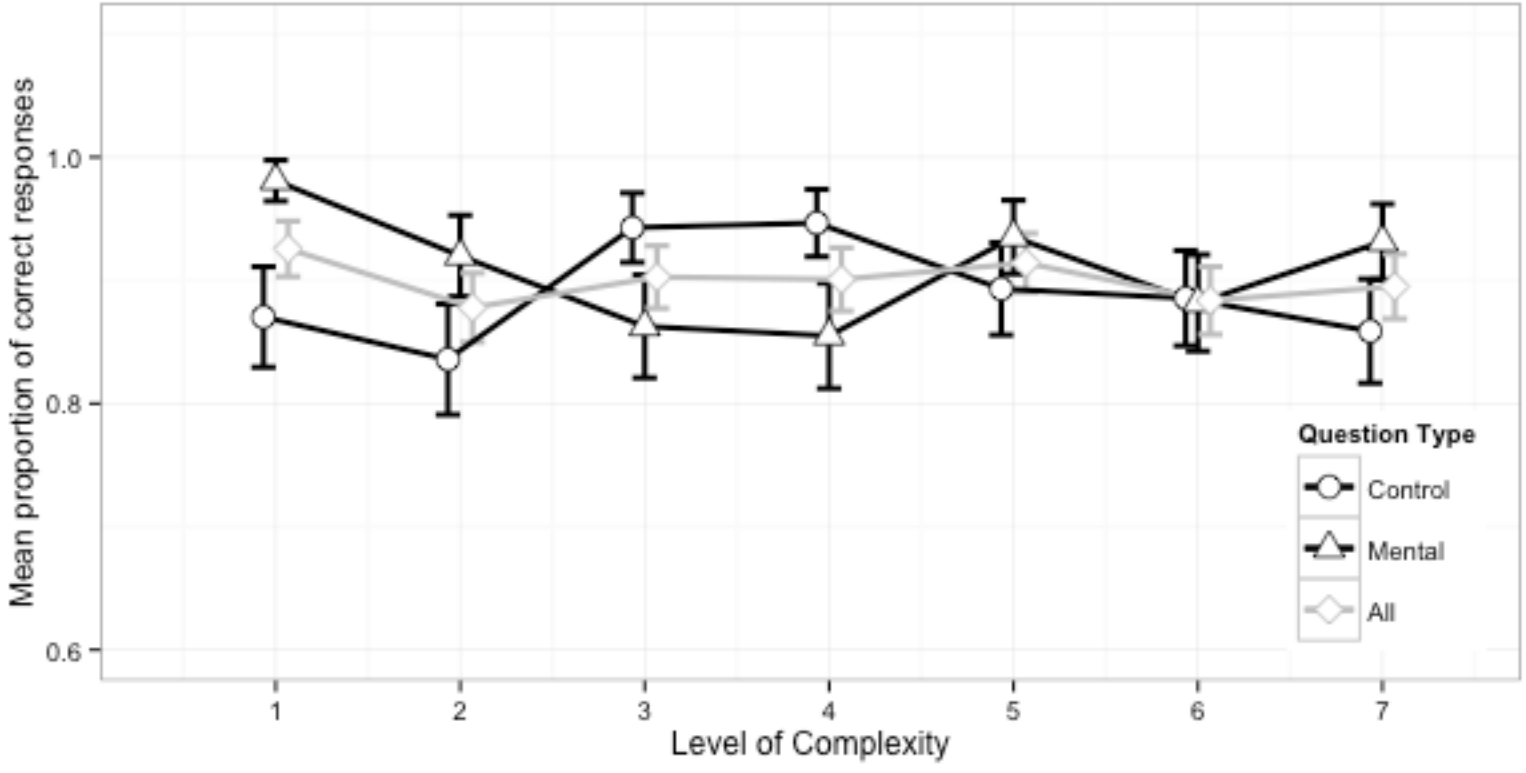
Figure Legends

Figure 1: *Mean proportion correct (by participant) at each level of mindreading*. Error bars give 95% CIs. These data show that performance on both mental and control tasks does not decrease as the level of embedding increases.

Figure 2: *The Condition* x *Story Presentation (left) and Story Presentation* x *Question Presentation (right) interactions for accuracy*. Bars give means of the by-participant mean success rates, error bars indicate 95% CIs. These results show that for control questions, performance was lower when the stories were presented implicitly rather than explicitly (left-hand side), and that performance was reduced when stories were presented implicitly and questions explicitly, in comparison to all other possible combinations of story presentation and questions presentation (right-hand side). These were the only significant interactions for accuracy.

Figure 3: *Mean confidence (by participant)*. Error bars give 95% CIs. These data show that although actual performance (i.e. accuracy) does not decrease as the level of embedding increases (see Figure 1), our participants' confidence in their answers does decrease.

Figure 4: *Number of additional video views for each combination of condition and question presentation*. Error bars give 95% CIs. These results show that for all control questions (i.e. both implicit and explicit), and for mental questions that were presented explicitly, participants chose to watch the videos increasingly often as level increased. This was, however, not true for mental questions presented implicitly, for which there was no corresponding increase with level. Given that this reduction in the number of views did not lead to any reduction in actual performance (see Figures 1 and 2), this is tentative evidence that the implicit mental questions were processed more easily than all other types of question. In the Discussion we suggest that this may be because recursive mindreading is actually easy, when presented within is natural social context.


Mean proportion of correct responses
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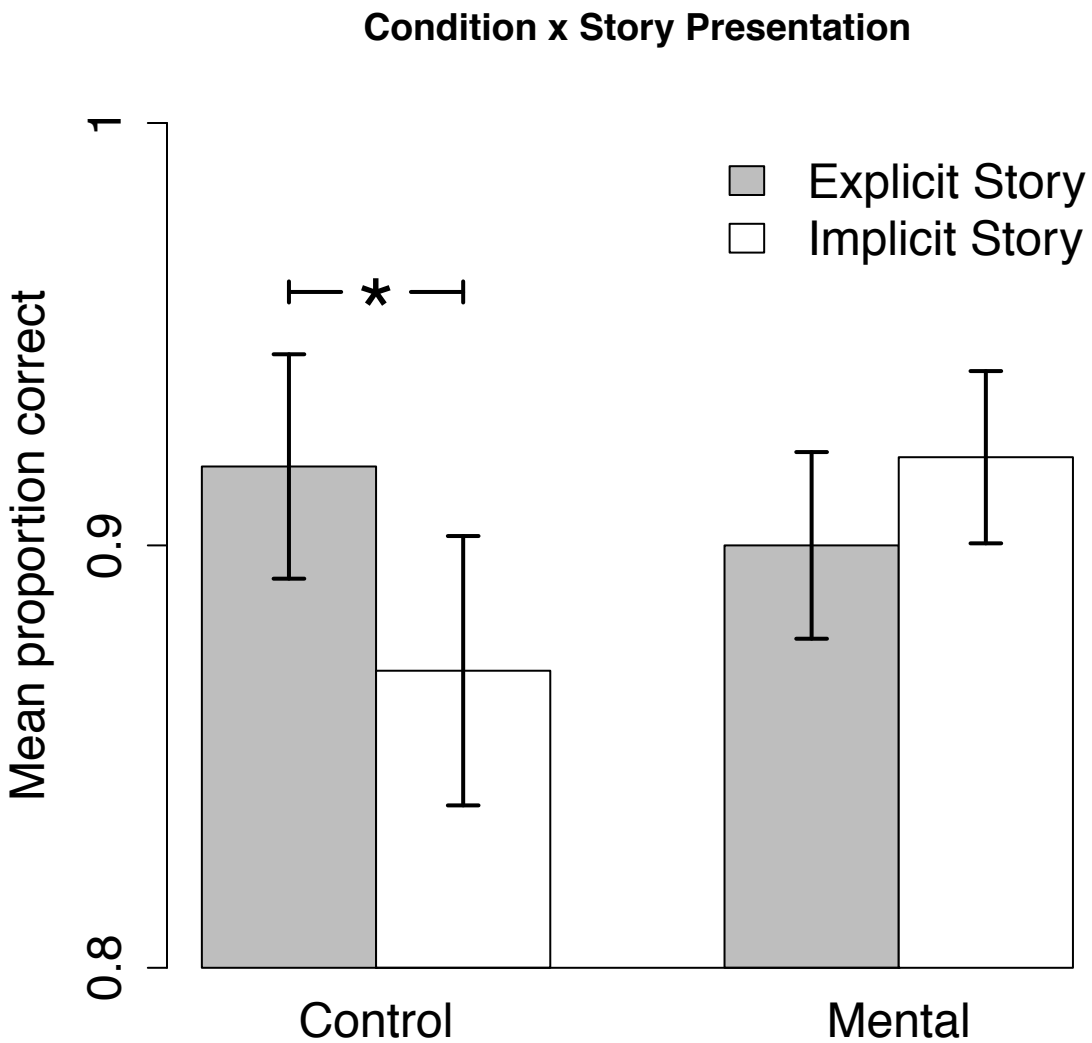
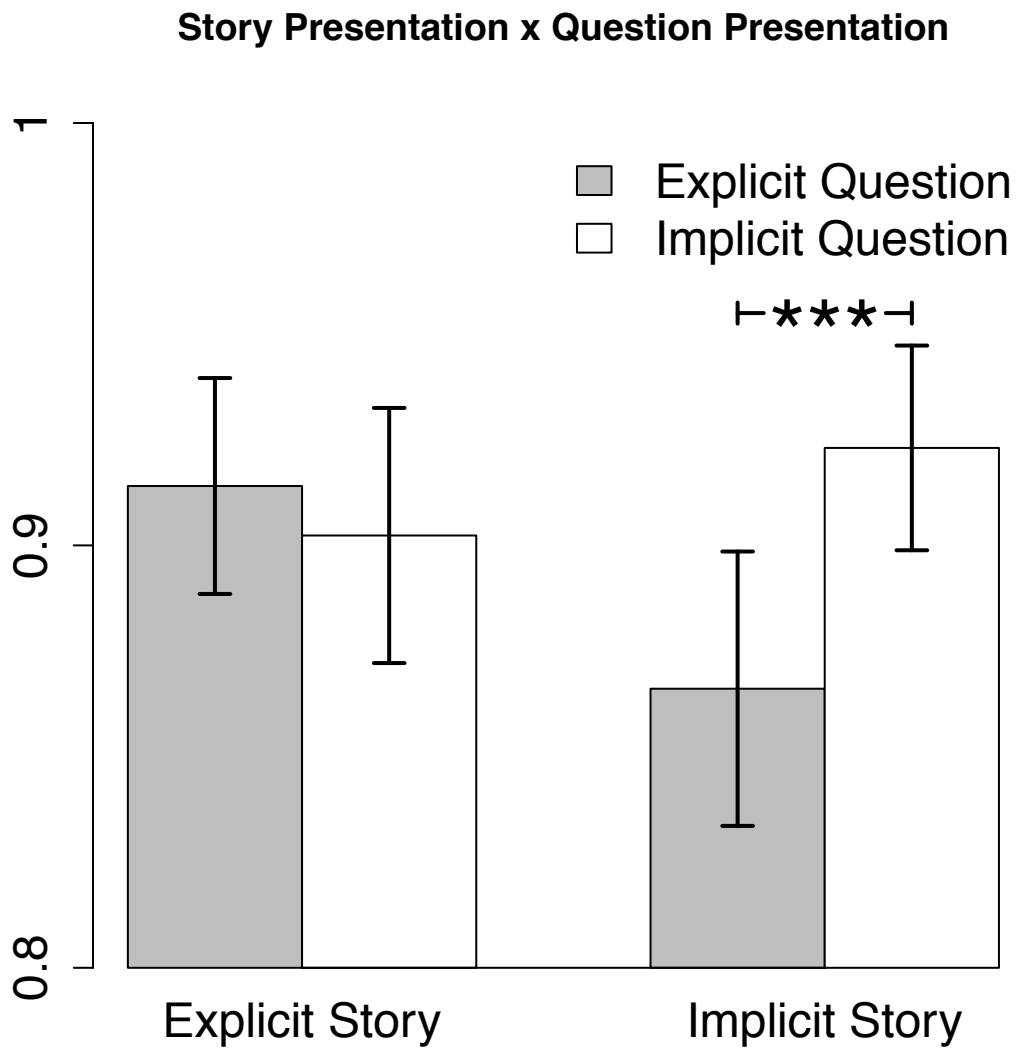
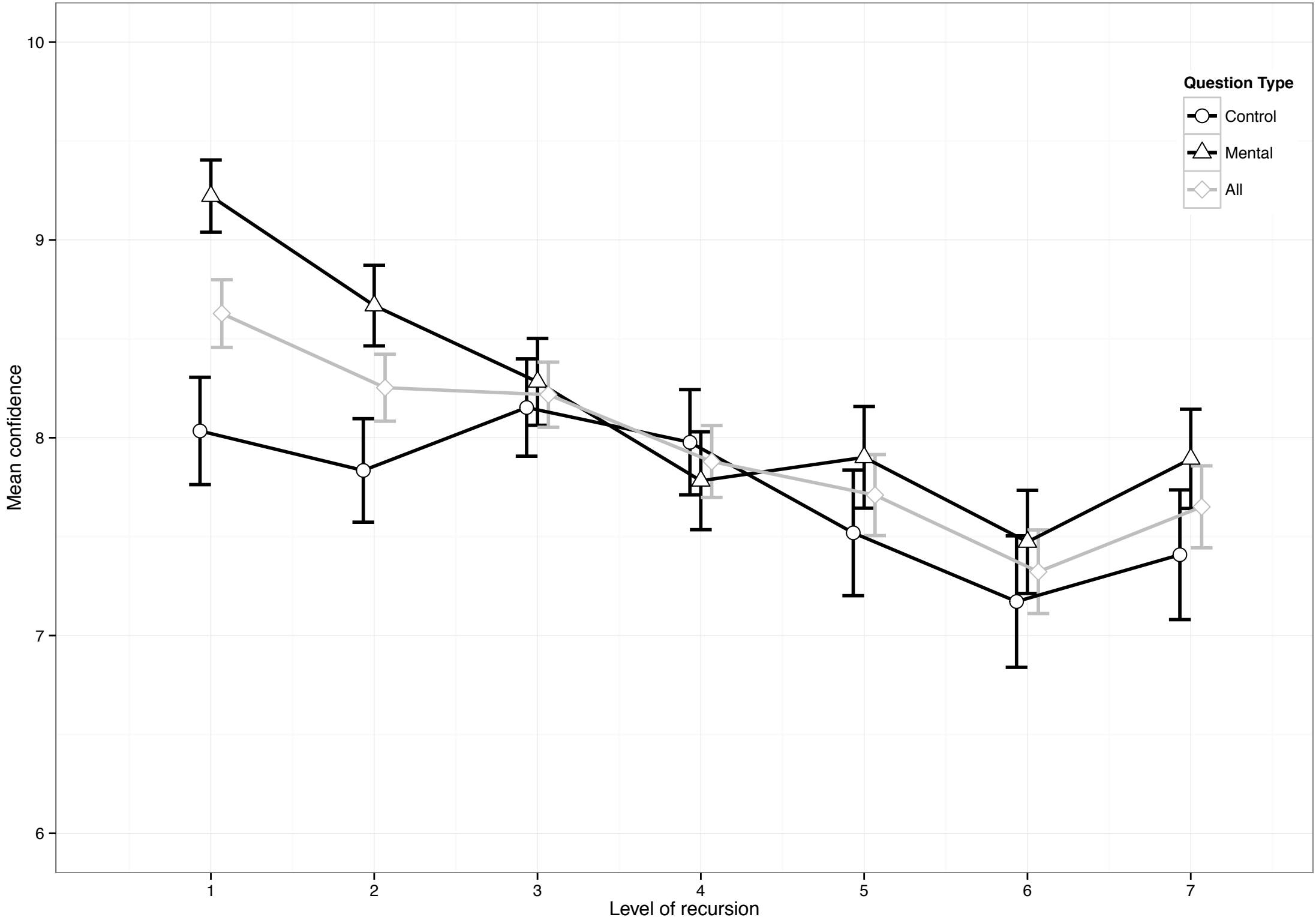
0.8
0.6
1
2
3
4
5
6
7
Level of Complexity
Question Type
Control
Mental
All


Condition x Story Presentation
Mean proportion correct
1
0.9
0.8
Explicit Story
Implicit Story
*
Control
Mental


Story Presentation x Question Presentation
1
0.9
0.8
Explicit Question
Implicit Question
***
Explicit Story
Implicit Story


Question Type
Control
Mental
All
Mean confidence
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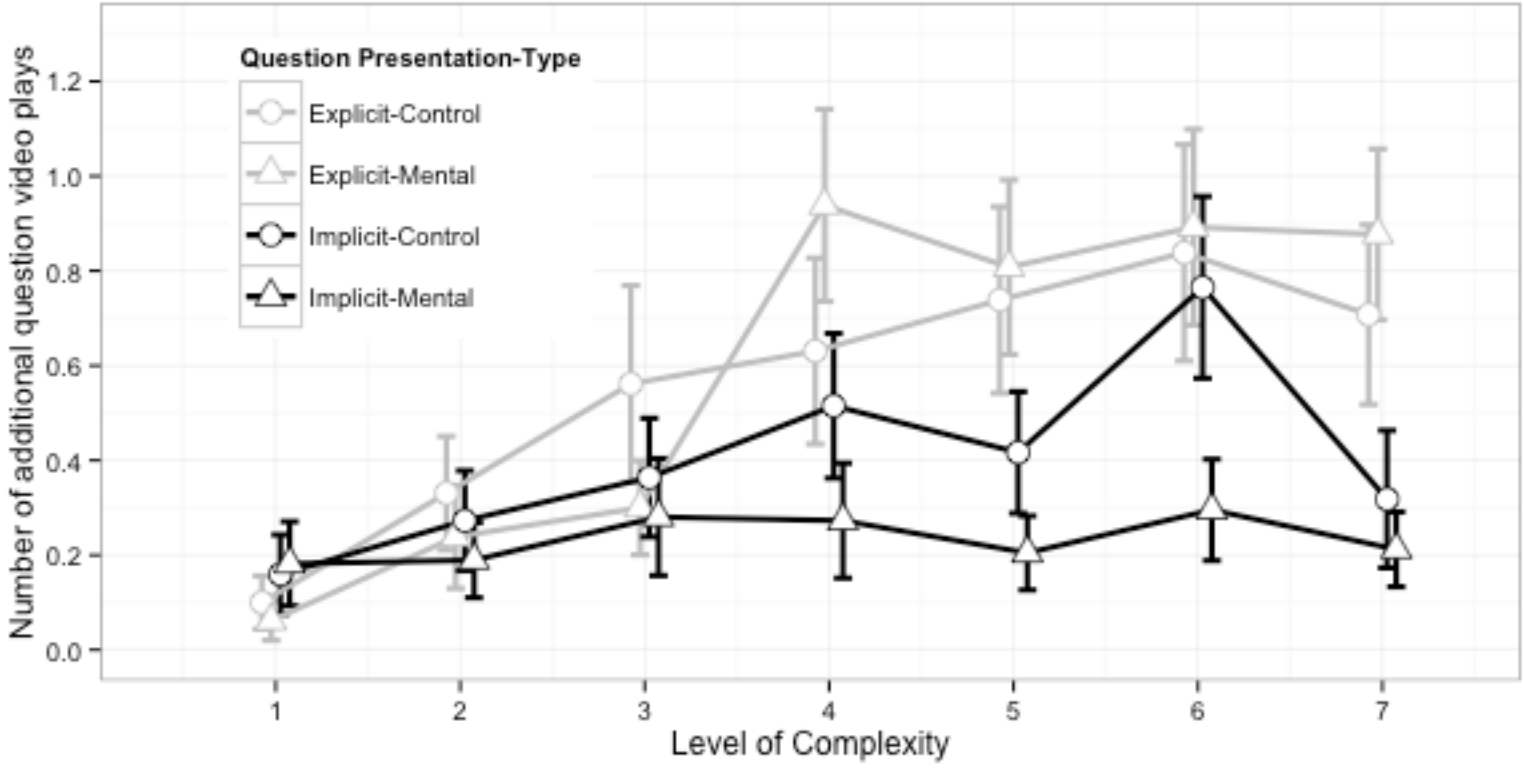
9
8
7
6
1
2
3
4
5
6
7
Level of recursion


Question Presentation-Type
Explicit-Control
Explicit-Mental
Implicit-Control
Implicit-Mental
Number of additional question video plays
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1
2
3
4
5
6
7
Level of Complexity

Stimuli

A: Narrated stories

Story 1: Bernard

One evening, Megan finds out that her sister Lauren wants to go out with a boy in her Biology class, Stephen. Megan tells Lauren that Stephen used to be best friends with a boy called Chris, who is now Megan's best friend. Lauren tells Megan that she saw Stephen smiling and flirting with their cousin, Elaine, and so she thinks Stephen might want to go out with Elaine. Because Lauren thinks Stephen likes someone else, she is too nervous to ask him out.

Megan talks to Elaine at school and finds out that Elaine actually wants to go out with Bernard, whom Megan knows from the school play. Megan learns that Elaine and Bernard are next-door neighbours, and that Bernard thinks that Elaine doesn't know him well enough to date. Elaine tells Megan that Stephen knows how Elaine feels about Bernard and how Bernard feels about Elaine.

Megan later talks to her friend Chris about the situation, realising that if Lauren knew about Elaine's situation, and knew that Stephen knows about it too, Lauren would realise that Stephen doesn't want to go out with Elaine, and might work up the courage to ask him out. Megan plans to tell Lauren about everything that evening.

Mental questions

1. A. Elaine likes Bernard
   B. Elaine likes Stephen
2. A. Megan knows that Lauren wants to ask Stephen out
   B. Megan doesn't know that Lauren wants to ask Stephen out
3. A. Elaine doesn't know that Bernard feels that she doesn't know him well enough to

date

B. Elaine knows that Bernard feels that she doesn't know him well enough to date

4. A. Stephen knows that Elaine knows that Bernard feels she doesn't know him well enough to date

   B. Stephen doesn't know that Elaine knows that Bernard feels she doesn't know him well enough to date

5. A. Megan knows that Stephen doesn't know that Elaine knows that Bernard feels that she doesn't know him well enough to date

   B. Megan knows that Stephen knows that Elaine knows that Bernard feels that she doesn't know him well enough to date

6. A. Chris knows that Megan knows that Stephen knows that Elaine knows that Bernard feels that she doesn't know him well enough to date

   B. Chris doesn't know that Megan knows that Stephen knows that Elaine knows that Bernard feels that she doesn't know him well enough to date

7. A. Megan wants Lauren to know that she, Megan, knows that Stephen knows that Elaine knows that Bernard feels she doesn't know him well enough to date, so that Lauren asks Stephen out

   B. Megan doesn't want Lauren to know that she, Megan, knows that Stephen knows that Elaine knows that Bernard feels she doesn't know him well enough to date, so that Lauren doesn't ask Stephen out

Control questions

1. A. Lauren is Megan's sister

   B. Lauren is Megan's friend

2. A. Stephen has Biology with Megan's sister Lauren

   B. Stephen was in the school play with Megan's friend Chris

3. A. Chris used to be best friends with Stephen, who has Biology with Megan's sister

   B. Chris used to be best friends with Bernard, who acted in the school play with Megan's sister

4. A. Megan is best friends with Chris, who used to be best friends with Stephen, who has Biology with Megan's sister Lauren

   B. Megan's sister Lauren used to go out with Chris, who is best friends with Elaine, who has Biology with Stephen

5. A. Bernard acted in the play with Megan, who is the best friend of Chris, who used to be best friends with Stephen, who takes Biology with Lauren who is Megan's sister

   B. Bernard acted in the play with Lauren, who used to go out with Chris, who used to be best friends with Stephen, who lives next door to Elaine who is Lauren's cousin

6. A. Elaine lives next door to Bernard, who acted in the play with Megan, who is the best friend of Chris, who used to be best friends with Stephen, who takes Biology with Lauren, who is Megan's sister

   B. Elaine lives next door to Bernard, who is the best friend of Chris, who used to be best friends with Stephen, who was in the play with Lauren's sister Megan, who has Biology with Elaine

7. A. Megan's cousin is Elaine, who lives next door to Bernard, who acted in the play with Megan, who is the best friend of Chris, who used to be best friends with Stephen, who has Biology with Megan's sister Lauren

   B. Megan's cousin is Elaine, who has Biology with Bernard, who acted in the play with Stephen, who used to go out with Megan, who is the best friend of Chris, who has Biology with Megan's sister Lauren

Story 2: Michelle and Nick

Nick and Michelle, who have been friends for a very long time, started dating recently, on

November 22nd. They were at a beautiful pre-Thanksgiving wedding, and Nick had managed to get tipsy before the ceremony, so they went for a walk in the afternoon to help him walk it off. When they got back from the walk, Nick asked Michelle if she'd consider dating him, and she said yes.

Michelle is really crazy about Nick, but she is worried that he doesn't feel the same, because he doesn't want them to break the news to all their friends. Although Nick has told her that he feels it's too early to tell people, she is worried that he doesn't want to tell people because he actually doesn't like her all that much.

Michelle tells her friend Rebecca about the relationship and about how she and Nick started dating. She and Rebecca argue over some of the details – Rebecca thought the wedding was after Thanksgiving, on November 29th, but Michelle reminds her that it was definitely the 22nd, because that was the morning when Richard got his puppy. Michelle tells her friend Rebecca about her concerns about Nick's feelings, and Rebecca advises her to talk to Nick about it.

Meanwhile, Nick has actually told a mutual friend, James, about his relationship with Michelle. He tells James that he is so excited about the relationship that he is terrified of telling people in case the pressure makes him mess everything up. Rebecca walks in and overhears the conversation, finding out Nick's real reason for keeping the relationship secret. While she thinks it is sweet, she is also annoyed at him for not being honest with Michelle, because the reason he gave Michelle is causing her anxiety. She then gets angry with James for being in on Nick's lie.

Rebecca realises that she can get Nick and James to tell Michelle the truth by threatening to tell Michelle's big brother, Richard. Richard is very protective of Michelle and Rebecca points out that he will be very angry if he finds out what Rebecca knows about Nick lying to Michelle and James protecting Nick. Rebecca promises to tell Richard if the two of them don't sort out the situation. She thinks to herself with satisfaction that they will tell Michelle without her having to intervene any further.

Mental questions

1. A. Nick is scared to tell people about his relationship with Michelle.
   B. Nick doesn't like Michelle enough to tell people he is dating her.
2. A. Michelle believes that Nick thinks it's too early to tell people about their relationship because he doesn't like her all that much.
   B. Michelle knows that Nick thinks too much outside attention will put pressure on their new relationship.
3. A. Nick doesn't know that Michelle is worried that he doesn't like her enough to want to tell people.
   B. Nick is fully aware that Michelle is worried that he doesn't like her enough to want to tell people.
4. A. James knows that Nick wants Michelle to believe that Nick thinks it's too early to tell people.
   B. James doesn't know that Nick wants Michelle to believe that Nick thinks it's too early to tell people.
5. A. Rebecca knows that James knows that Nick does not intend Michelle to know that he is scared of too much attention ruining their relationship.
   B. Rebecca doesn't know that James knows that Nick does not intend Michelle to know that he is scared of too much attention ruining their relationship.
6. A. James thinks that if Richard knows that James knows that Nick wants Michelle to believe that he thinks it's too early to tell people, Richard will be really angry.
   B. James doesn't think that if Richard knows that James knows that Nick wants Michelle to believe that he thinks it's too early to tell people, Richard will be really angry.
7. A. Rebecca intends that Richard knows that she knows that James knows that Nick

wants Michelle to believe that he thinks that it's too early to tell people.

B. Rebecca doesn't intend that Richard knows that she knows that James knows that Nick wants Michelle to believe that he thinks that it's too early to tell people.

Control questions

1. A. Michelle and Nick started dating after a walk in the park.

   B. Michelle and Nick started dating during a walk in the park.

2. A. Michelle and Nick started dating after a walk in the park, when Nick was tipsy.

   B. Michelle and Nick started dating during a walk in the park, when Nick was tipsy.

3. A. Michelle and Nick started dating in the afternoon, after a walk in the park, when Nick was tipsy.

   B. Michelle and Nick started dating in the morning, during a walk in the park, before Nick got tipsy.

4. A. Michelle and Nick started dating after a walk in the park, when Nick was tipsy, in the afternoon, on November 22nd.

   B. Michelle and Nick started dating during a walk in the park, in the morning, on November 22nd, before Nick got tipsy.

5. A. Michelle and Nick started dating after a walk in the park, when Nick was tipsy, in the afternoon, on November 22nd, before Thanksgiving B.

   B. Michelle and Nick started dating when Nick was tipsy, during a walk, in the morning, on November 29th, after Thanksgiving.

6. A. Michelle and Nick started dating after a walk in the park, when Nick was tipsy, in the afternoon, on November 22nd, before Thanksgiving, at a wedding.

   B. Michelle and Nick started dating before a wedding, in the morning, on November 22nd, after Thanksgiving, during a walk in the park, before Nick got tipsy.

7. A. Michelle and Nick started dating after a walk in the park, when Nick was tipsy, in the afternoon, on November 22nd, before Thanksgiving, at a wedding, before the

ceremony.

B. Michelle and Nick started dating at a wedding, after the ceremony, in the morning, on November 29th, before Thanksgiving, during a walk in the park, when Nick was tipsy.

Story 3: Babysitting

Haley has been grounded by her parents. She is desperate to get out of the house and spend some time with her boyfriend, so she starts looking for something that she will be allowed to do while she is grounded. She decides to try and find a babysitting job. Haley tries to work out who will let her babysit for them. She thinks about her new stepfather, Peter, and the whole crazy family he has brought along with him. Peter's sister Kirsty has just adopted a baby, Lily, with her husband, Ed. Haley knows that Ed is really fun and relaxed and so she decides to try to persuade him to let her babysit Lily. Ed realises that Haley knows absolutely nothing about babies and refuses to let her babysit.

Later, Ed goes to visit his father, Jay, and Jay's young new wife, Anna, who has a son called Martin. Ed and Anna sit and discuss what to do about Haley. Ed is worried that Kirsty will feel insulted if Ed refuses to let Kirsty's new step-niece babysit for them, but feels that he has to let Kirsty know that Haley knows nothing about babies. Peter, Haley's stepfather, overhears the conversation and finds out that Ed is intending to convince Kirsty that Haley is clueless about babysitting.

Trying to be a good stepfather, Peter tells Claire, Haley's mom, about what he has heard. She happens to agree with Ed that Haley would make the world's worst babysitter, but wants to protect Haley – she realises that if Haley discovered that her Mom knew what Peter had heard, Haley would be hurt and upset. Claire and Peter decide not to tell her about what they know.

Mental questions

1. A. Haley doesn't know anything about looking after babies.
   B. Haley knows a lot about looking after babies.
2. A. Kirsty doesn't know that Haley knows nothing about babies.
   B. Kirsty knows that Haley knows nothing about babies.
3. A. Ed wants Kirsty to know that Haley doesn't know enough to babysit.
   B. Ed doesn't want Kirsty to know that Haley doesn't know enough to babysit.
4. A. Peter knows that Ed wants Kirsty to find out that Haley knows nothing about babies.
   B. Peter doesn't know that Ed wants Kirsty to find out that Haley knows nothing about babies.
5. A. Claire knows that Peter knows that Ed wants Kirsty to believe that Haley knows nothing about babies.
   B. Claire doesn't know that Peter knows that Ed wants Kirsty to believe that Haley knows nothing about babies.
6. A. Claire thinks that if Haley knew that Claire knew that Ed wanted Kirsty to believe that Haley knew nothing about babies, Haley would be really upset.
   B. Claire doesn't think that if Haley knew that Claire knew that Ed wanted Kirsty to believe that Haley knows nothing about babies, Haley would be really upset.
7. A. Claire intends that Haley never knows that Claire knows that Peter knows that Ed wants Kirsty to believe that Haley knows nothing about babies.
   B. Claire intends that Haley knows that Claire knows that Peter knows that Ed wants Kirsty to believe that Haley knows nothing about babies.

Control questions

1. A. Claire is Haley's mother.

B. Claire is Haley’s aunt.

2. A. Peter is Haley’s mother’s husband.

B. Peter is Haley’s mother’s brother.

3. A. Kirsty is Haley’s mother’s husband’s sister.

B. Kirsty is Haley’s aunt’s husband’s cousin.

4. A. Ed is Haley’s mother’s husband’s sister’s husband.

B. Ed is Haley’s mother’s brother’s wife’s stepfather.

5. A. Jay is Haley’s mother’s husband’s sister’s husband’s father.

B. Jay is Haley’s mother’s husband’s brother’s wife’s father.

6. A. Anna is Haley’s mother’s husband’s sister’s husband’s father’s wife.

B. Anna is Haley’s father’s wife’s brother’s wife’s father’s sister.

7. A. Martin is Haley’s mother’s husband’s sister’s husband’s father’s wife’s son.

B. Martin is Haley’s mother’s husband’s brother’s wife’s father’s sister’s son.

Story 4: Sheila's Problem

John and Sheila work in an office together. Sheila works in Finance and has a great working relationship with her supervisor, Mike. Mike’s boss Courtney has recently hired a new PA called John, who has developed a crush on Sheila. One day, after an extremely awkward encounter with John, Sheila tells her friend and colleague Amy about John’s crush. She and Sheila agree that it would be best to just let John believe that Sheila hasn’t noticed anything odd.

Later, at the pub, John tells his best friend Tim about his crush on Sheila. He is worried that things could be very uncomfortable at the office if Sheila knew that he has a crush on her, but he is fairly confident that she hasn’t yet realised. Tim’s girlfriend is Amy, the same colleague that Sheila has told about John’s crush. Tim tells Amy about John’s crush on Sheila, and Amy tells Tim that Sheila told her about it earlier that day. Tim is worried about John – he knows

that John would be mortified if he realised that Sheila knew about his feelings for her. Amy reassures Tim that Sheila intends to keep John in the dark by acting normally, so that he never realises that she's figured it out.

Amy realises that there is another person who needs to know about this whole situation: Victor. Victor is her brother Shaun's best friend, and he is married to Sheila. Even if there is nothing going on between Sheila and John, Amy thinks that Victor deserves to know about the situation. She tells him about John's crush and Sheila's plan to keep the office environment comfortable. It turns out that Victor knew about the whole plan.

Mental questions

1. A. John likes Sheila.
   B. John likes Amy.
2. A. Sheila knows that John likes her.
   B. Sheila doesn't know that John likes her.
3. A. John thinks that Sheila hasn't realised that he likes her.
   B. John thinks that Sheila has realised that he likes her.
4. A. Sheila intends that John thinks that she hasn't realised that he likes her.
   B. Sheila doesn't intend that John thinks that she hasn't realised that he likes her.
5. A. Amy knows that Sheila intends that John thinks that she hasn't realised that he likes her.
   B. Amy doesn't know that Sheila intends that John thinks that she hasn't realised that he likes her.
6. A. Victor knows that Amy knows that Sheila intends that John thinks that she hasn't realised that he likes her.
   B. Victor doesn't know that Amy knows that Sheila intends that John thinks that she

hasn’t realised that he likes her.

7. A. Amy intends that Victor knows that Amy knows that Sheila intends that John thinks that she hasn’t realised that he likes her.

   B. Amy does not intend that Victor knows that Amy knows that Sheila intends that John thinks that she hasn’t realised that he likes her.

Control questions

1. A. Mike is Sheila’s supervisor.

   B. Mike is Sheila’s PA.

2. A. Courtney is Sheila’s supervisor Mike’s boss.

   B. Courtney’s is Sheila’s PA Mike’s supervisor.

3. A. John is Sheila’s supervisor Mike’s boss’s PA.

   B. John is Sheila’s PA Mike’s boss’s supervisor.

4. A. Tim is Sheila’s supervisor Mike’s boss’s PA John’s best friend.

   B. Tim is Sheila’s best friend Mike’s boss’s PA John’s supervisor.

5. A. Amy is Sheila’s supervisor Mike’s boss’s PA John’s best friend’s girlfriend.

   B. Amy is Sheila’s PA Mike’s supervisor’s boss John’s best friend’s girlfriend.

6. A. Shaun is Sheila’s supervisor Mike’s boss’s PA John’s best friend’s girlfriend Amy’s brother.

   B. Shaun is Sheila’s best friend Mike’s supervisor’s boss John’s PA’s girlfriend Amy’s brother.

7. A. Victor is Sheila’s supervisor Mike’s boss’s PA John’s best friend’s girlfriend Amy’s brother’s friend.

   B. Victor is Sheila’s best friend Mike’s brother’s boss John’s supervisor’s PA Amy’s girlfriend’s friend.

B: Scripts

Story 1: Bernard

Scene 1

Megan:	Lauren, your phone just buzzed.
	Lauren snatches up her phone
Megan:	Ooooh, is that a booooy?
Lauren:	Maybe…OK, OK, it's Stephen. You know, the one in my Biology class.
Megan:	Oh, I didn't know you had a thing for him. Did you know he used to be best friends with Chris?
Lauren:	Which Chris?
Megan:	The Chris who's my best friend. Yeah, they were friends in primary school.
Lauren:	That's weird. Anyway…I was actually thinking about working up the guts to ask him out, but I'm nervous.
Megan:	Haha, you'd better not let our Dad find out…Anyway, why are you nervous? I'm sure he'll say yes.
Lauren:	Well, I saw him chatting to Elaine at lunchtime the other day, and he was all smiley and flirty, so I think he's planning to ask her out.

Scene 2

Megan: Hey Elaine!

Elaine: Oh, hey cousin, could you hold this for a second?

Megan: So, I saw you flirting with Stephen the other day…he's cute!

Stephen walks past them, they pause awkwardly and giggle

Elaine: Haha, yup, he is, but there's nothing going on.

Megan: Why not?

Elaine: I kind of have a thing for Bernard…

Megan: Bernard? The one who was in the school play with me?

Elaine: Yeah, that's the one.

Megan: Oh, I didn't know you guys knew each other.

Elaine: I live next door to him. Anyway, he doesn't like me back.

Megan: Why on earth not?

Elaine: Well, I dunno if it's that he doesn't like me, it's more just that he thinks I don't know him well enough to really want to date him. He says if I knew him better I wouldn't want to…really weird.

Megan: Ugh, he's just being melodramatic. I'm sure

he'll come round. Does Stephen know? He looked pretty into you when you were chatting.

Elaine: Yup, I told him about it ages ago, we were just laughing about Mr Murray's new haircut.

Megan: Ah, OK. Anyway, I'd better run – hope Bernard realises what he's missing!

Scene 3

Megan: …so it turns out that Elaine and Stephen aren't into each other at all. Elaine is actually really into Bernard.

Chris: The acting one?

Megan: Yeah. Bernard's super melodramatic, too – he doesn't want to date Elaine because he reckons Elaine doesn't know him well enough or something.

Chris: That's weird. And Stephen knows that Elaine's not into him?

Megan: Mm, Elaine told him about the whole Bernard thing ages ago.

Chris: So Lauren…

Megan: Right! So, Lauren doesn't want to ask Stephen out because she thinks he's into Elaine – but if she knew that Stephen knows that Elaine likes Bernard, and that Stephen knows that Elaine's

not into him, she might work up the guts to ask Stephen out.

Chris: I guess…so are you going to tell her?

Megan: Yeah, I'm going to tell her the whole thing tonight.

Mental questions

1. A. Elaine: Ahhh, there goes Bernard, he's so cute…can't remember the last time I liked someone so much.

   B. Elaine: Ahhh, there goes Stephen, he's so cute…can't remember the last time I liked someone so much.

2. A. Chris: I heard your sister wants to ask Stephen out!

   Megan: What? She hasn't told me that!

   B. Chris: Lauren told me today that she wants to ask Stephen out. .

   Megan: Oh, yeah, she told me about it last night

3. A. Elaine: I worked up the guts to ask Bernard out today. He said no, but I have no idea why he won't go out with me

   B. Elaine: I worked up the guts to ask Bernard out today. He said no. He reckons I don't know him well enough

4. A. Megan: Hey, Stephen, I thought you should know something.

   Stephen: Yeah?

   Megan: It's about Elaine – you know she has a thing for Bernard?

   Stephen: Yeah, and he doesn't want to go out with her because he thinks she doesn't know him enough? Poor girl, she was crushed when she found out

   B. Megan: Oh, I have some hot gossip – did you hear about Elaine?

   Stephen: No – what about her?

Megan: She's really into Bernard, but Bernard doesn't like her back because he thinks Elaine doesn't know him well enough.

Stephen: Seriously? That's a weird reason not to go out with someone. Why didn't Elaine tell me about this?

5. A. Megan: So Elaine told me today that she has a thing for Bernard, but Bernard doesn't like her back because he thinks Elaine doesn't know him well enough.

Chris: Elaine has a thing for Bernard? But I saw her flirting with Stephen!

Megan: Mm-hmm, and Stephen has no idea, either that Elaine likes Bernard, or that Bernard doesn't like her back.

Chris: Yikes, that's not cool – she needs to tell him.

B. Megan: So Elaine told me today that she has a thing for Bernard, but Bernard doesn't like her back because he thinks Elaine doesn't know him well enough.

Chris: Elaine has a thing for Bernard? But I saw her flirting with Stephen!

Megan: Oh, yeah, he knows, she told him.

Chris: Knows which bit?

Megan: Knows that Elaine likes Bernard and that Bernard told Elaine that he won't go out with her.

6. A. Chris: Yeah, so Megan heard some juicy gossip today…Stephen too? Haha, I bet it's the same gossip – they both know about this, anyway…So you know Elaine? She has a mega thing for Bernard…uh-huh…and Bernard told her – yeah, told Elaine – that he doesn't want to go out with her because Elaine doesn't know him well enough. I know, it's weird, right? So, wait, you spoke to Megan earlier and asked her about Elaine and Stephen, and Megan

said she didn't know anything about it? That's weird, she *definitely* knows.

B. Chris: Yeah, so what's this hot gossip? Elaine and Bernard? Why not? Because she doesn't know him well enough? That's weird…does Stephen know? Ok, that's good, it would be really awful of Elaine if he didn't. And Megan knows too? What? Has she heard that Stephen knows about all of it? That's weird, Megan didn't tell me anything.

7. A. Megan: So, I'm thinking that Lauren needs to know what I heard. Right? Because if she knows what I know right now, about Elaine's crush, and Bernard's rejection, and that Stephen knows the whole thing…she'll work up the guts to ask him out! So I'm going to tell her tonight.

B. Megan: Well, if you think about, if Lauren knew what I heard today – and if she knew that Stephen knew all about it too, about Elaine's crush and Bernard's weird reason for rejection and everything – she'd ask Stephen out. But I don't want her to do that, so I'm not going to tell her.

Control questions

1. A. Megan: So I was chatting to my friend, Lauren…

B. Megan: So I was chatting to my sister, Lauren…

2. A. Megan: You know Stephen? The one who has Biology with my sister Lauren?

B. Megan: You know Stephen? The one who was in the school play with my friend Chris?

3. A. Megan: Did you know that Chris used to be best friends with Stephen?

Elaine: Which Stephen?

Megan: The one who has Biology with my sister Lauren.

B. Megan: Did you know that Chris used to be best friends with Bernard?

Elaine: Which Bernard?

Megan: The one who was in the school play with my sister Lauren.

4. A. Megan: You know Stephen, who has Biology with my sister? He used to be best friends with my best friend, Chris.

   B. Megan: You know my sister Lauren used to go out with Chris, who's best friends with Elaine? She has Biology with Stephen.

5. A. Elaine: No, the other Megan, the one whose best friend Chris used to be best friends with this guy Stephen who has Biology with Lauren, Megan's sister…yeah, she knows Bernard from the school play.

   B. Elaine: No, the other Lauren, the one who used to go out with that Chris guy who used to be best friends with Stephen…yeah, Stephen who lives next door to me. Yup, that's the Lauren who's my cousin.

6. A. Elaine: You know Bernard, who was in the play with Megan? No, the Megan whose best friend is that Chris guy, the one who used to be best friends with Stephen…nuh-uh, the other Stephen, the one who has Biology with Megan's sister Lauren. Yeah, that Megan. Remember she co-starred with Bernard? That's my next-door neighbour.

   B. Elaine: You know Bernard, Chris's best friend? No, the Chris who used to be best friends with Stephen, that guy who starred in the play with Lauren's sister Megan, who's in Biology with us. Yeah, that Bernard is my next-door neighbour.

7. A. Megan: My cousin, Elaine, the one who lives next door to Bernard? Argh, you know Bernard. He was in the play with me and my best friend Chris…Chris who used to be best friends with Stephen, the guy in Biology with my sister Lauren.

   B. Megan: You know my cousin Elaine, who has Biology with Bernard? Argh, you know Bernard…he acted in the play with my ex, Stephen, and my best

friend Chris…Chris who has lives next door to me and my sister Lauren.

Story 2: Michelle and Nick

Scene 1: Michelle is upset, Rebecca enters and sees

Rebecca: Hey, honey, what's wrong?

Michelle: I guess I might as well tell you.

Rebecca: Tell me what?

Michelle: It's about Nick…we kinda hooked up in November just before Thanksgiving, at that wedding.

Rebecca: Wait, what? The wedding in November? That was after Thanksgiving.

Michelle: No, definitely before, it was November 22nd.

Rebecca: No, it was November 29th.

Michelle: Nope, definitely the 22nd – remember, that was the morning when Richard got his puppy?

Rebecca: Oh, yeah, you're right. Anyway, carry on.

Michelle: Yeah. Nick had too much champagne before the ceremony and got tipsy, so we went for a walk that afternoon to help him walk it off. When we got back, he asked me if I'd consider dating him…but now I'm feeling like maybe he regrets it.

Rebecca: Why?

Michelle: Well, he doesn't want to tell anyone about us, and he says it's just too early, but I think

maybe he just doesn't like me enough to tell anyone.

Rebecca: Sweetie, I really think you need to talk to Nick about this. He's probably really crazy about you and just hasn't realised he's upsetting you.

Michelle: OK, I'll talk to him.

Scene 2: Nick talking to James

James: So, how's it going with Michelle? She still thinks you haven't told anyone, right?

Nick: Yeah. I've been trying to play it cool, making her think I just believe it's too early to tell people, but the truth is I'm just really scared that if people find out, there'll be so much pressure on me and I'll mess it up. But I really want to carry on – this is the best relationship I've been in forever.

Rebecca enters, quietly

James: And you're going to keep letting her believe that?

Nick: Yeah, it's easier that way.

Rebecca: Letting who believe what?

James: C'mon, man, I think you should tell her.

Nick: OK, OK, I didn't want to tell anyone just yet, but…Michelle and I have been seeing each

other for a while.

Rebecca: Oh my god, that's fantastic! Why haven't you told us yet? That's such good news!

Nick: Yeah, well, I'm just scared I'm going to mess it up and I guess I didn't want all eyes on me…

Rebecca: Aha!

Nick: What?

Rebecca: Michelle told me about you guys, idiot. And she's really upset and worried, because she thinks you don't like her enough to tell people you're together.

Nick: What?! That's insane! I'm crazy about her!

Rebecca: Well, then, I guess you'd better tell her the truth, hadn't you? It's not like she's going to be angry or anything. And at the moment she's really upset. (Rounding on James) And you knew about this?!

James: Ummmm…

Rebecca: You know who's going to be very interested to hear what I know? Mr Protective Big Brother…

James: Oh my god, Rebecca, please don't tell Richard.

Rebecca: Well, if you don't tell Michelle the truth by tonight, I will.

Rebecca leaves

Rebecca: Ha, that'll do the trick. I won't even have to tell Richard – they'll go running to Michelle straight away.

Mental questions

1. A. Nick: I'm really nervous to tell people in case it messes everything up.
   B. Nick: I'm not really that crazy about her and I'm not sure I want people knowing that we're dating.
2. A. Michelle: Nick doesn't want to tell anyone yet, and I think it's because he isn't really all that into me.
   B. Michelle: Nick doesn't want everyone to know because he's worried that having all eyes on us will put too much pressure on us.
3. A. Rebecca: You know she's worried sick that you're not telling people just because you're not really into her?
   Nick: What, that's what she thinks? I had no idea, that's crazy!
   B. Rebecca: You know she's worried that you don't really like her enough to tell people you're together?
   Nick: I know she's worried about that, but I have no idea what to do about it!
4. A. James: So Nick wants to keep Michelle believing that he thinks it's too early to tell people, even though he's really just scared to tell people because it will put pressure on the relationship.
   B. James: So Nick's going to just keep letting her believe that he thinks it's too early to tell people? That's insane – why didn't he tell me this? I would have told him it was a dumb plan.
5. A. Rebecca: So Nick, idiot that he is, is going to keep letting Michelle believe that he

thinks it's too soon to tell people! And James knew about this dumb plan, and did nothing about it!

B. Rebecca: So Nick, idiot that he is, is going to keep letting Michelle believe that he thinks it's too soon to tell people! No…no…I don't think James knew about it.

6. A. Rebecca: So James, you've been protecting Nick even though he's lying to Michelle by saying that he thinks it's too early to tell people? You know that Richard would be *furious* if he found out what I've just heard?

James: No, please don't tell him! Nick, you'll set this straight, right?

B. Rebecca: So James, you've been protecting Nick even though he's lying to Michelle by saying that he thinks it's too early to tell people? You know that Richard would be *furious* if he found out what I've just heard?

James: Pfft, Richard won't care about that.

7. A. Rebecca: So I'm thinking this evening, I'm going to give Richard a call, and tell him all that I've just heard about James, knowing that Nick has no intentions of letting Michelle know that he actually doesn't want to tell people because he's scared, and James doing nothing about it.

B. Rebecca: Haha, so then I told them that I was going to call Richard and tell him that James was protecting Nick in all his lies to Michelle – but I scared them so much that I don't have to do a thing.

Control questions

1. A. Michelle: Yeah, we started dating after we got back from this really romantic walk in the park.

B. Michelle: Yeah, we started dating during this really romantic walk in the park.

2. A. Nick: We started dating after a walk in the park, when I was kind of tipsy.

B. Nick: We started dating while we were walking in the park, while I was kind of tipsy.

3. A. Rebecca: They started dating one afternoon when Nick was tipsy, after they'd gone for a walk in the park.

B. Rebecca: They started dating one morning, while they were walking in the park, and when they got back, Nick got kind of tipsy.

4. A. Michelle: We started dating in the afternoon on November 22nd. We'd got back from a walk in the park, and Nick was a bit tipsy.

B. Michelle: We started dating in the morning on November 22nd, while we were walking in the park. When we got back, Nick got a bit tipsy.

5. A. Nick: We started dating before Thanksgiving, in the afternoon on November 22nd. I was a bit tipsy and we'd just got back from a walk in the park.

B. Nick: We started dating after Thanksgiving, in the morning on November 29th, while we were walking in the park. I was a bit tipsy at the time.

6. A. Michelle: We started dating before Thanksgiving, in the afternoon on November 22nd, after we got back from a walk in the park. We were at this wedding and Nick was a bit tipsy.

B. Michelle: We started dating after Thanksgiving, while we were waking in the park in the morning on November 22nd. After our walk we went to this wedding and Nick got a bit tipsy.

7. A. Rebecca: They started dating before the ceremony at this wedding, on the afternoon on November 22nd, before Thanksgiving. Nick was tipsy so they went for a walk in the park, and when they got back, he asked her out.

B. Rebecca: They started dating after the ceremony at this wedding, on the morning on November 29th, before Thanksgiving. Nick was tipsy so they went for

a walk in the park, and while they were there, he asked her out.

Story 3: Babysitting

Scene 1: Haley plots (on phone)

Haley: Well, I know I'm grounded, but I figured even my parents would let me out to babysit, right? So my new stepdad, Peter, has this sister, Kirsty, who's just adopted a baby with her husband Ed…and Ed's really cool and relaxed so I figured I'd try to get him to let me babysit…

Scene 2: Haley tries to persuade Ed to let her babysit Lily

Haley Come onnnnn! I just really need a break from my parents just for one night, and I know you need a babysitter…

Ed: Absolutely not. If you want a break you're welcome to come to movie evening but you are *not* looking after Lily. What do you know about babies?

Haley: Like, everything…what do you think I don't know?

Ed: Well, erm…OK, here's one. It's time to give Lily her bath. What temperature should the water be?

Haley: I dunno, like, bath temperature? I guess just

what I would find comfortable?

Ed: Uh-huh. And what would you feed her?

Haley: She's four months, right? And she's getting teeth? So…crackers? Or finger biscuits?

Ed: Yeah, you don't know anything about babies. You're not babysitting, and that's final.

Scene 3: Ed and Anna discuss Haley

Jay: (from offscreen) Hi honey, I'm home!

Anna: (calling offscreen) Jay! Your son is here!

Ed: calling offscreen Hi dad!

Jay: from offscreen Hi! Well, I have to go up to the office – if you see Peter, tell him I'm upstairs.

Ed: Where's Martin, Anna?

Anna: That naughty son of mine. He's upstairs playing with his friend.

Ed: Anyway, I have *got* to tell you about Haley. She's trying to babysit Lily for some reason and I asked her some basic questions to prove to her that she doesn't know the first thing about babies. And guess what? She thinks you can feed a four-month-old baby crackers!

Anna: That's hilarious.

Ed: Yeah…the thing is, Kirsty has no idea that she's so clueless and she's been suggesting

Haley as a sitter; I don't want to offend Kirsty, you know? 'Cause Haley is her step-niece and I think Kirsty's trying to reach out to the family…but I really need to persuade her that Haley's not competent.

(Peter enters)

Peter: Haley's not competent? What do you mean?

Anna: Hi, Peter…What are you doing here?

Peter: Jay needed some help fixing his printer. What do you mean, Haley's not competent?

Ed: Uh…as a babysitter.

Peter: What? That's outrageous, Haley would make a great sitter. She loves Lily to pieces.

Ed: Yeah, Peter, that's really not all that's needed for someone to be good with babies.

Peter: You've got to give her a chance at some point.

Scene 4: Peter tells Claire

Peter: And I heard them talking about how stupid Haley is when it comes to babies and how she'd make such a terrible sitter! How awful is that?

Claire: Uh, yeah, honey…Haley really would be the world's worst babysitter. I heard her say the other day that she saw some video about baby yoga where you swing the baby around by its

	ankles to get it used to having blood rush to its head.
Peter:	Huh. So…you're saying that we should let Ed talk Kirsty out of letting Haley babysit.
Claire:	Yeah, probably.
Peter:	But…if Haley found out that you knew what I'd heard she'd be really mad and upset with us.
Claire:	Yeah, you're right, she'd be sad that her mum didn't stand up for her. So we just won't let her find out that we know about it!

Mental questions

1. A. Haley: How should I know when to change Lily's nappy?
   B. Haley: It's important to sterilise the bottle before giving it to her.
2. A. Ed: Kirsty thinks it would be a great idea to get Haley to babysit.
   B. Ed: Nah, Kirsty would never want Haley to babysit - she knows Haley's clueless about babies.
3. A. Ed: I really need to persuade Kirsty that Haley doesn't know nearly enough about babies to look after Lily.
   B. Ed: I can't let Kirsty find out that Haley's clueless about babies! Kirsty would be so mad at me for thinking that.
4. A. Peter: Ed thinks Haley doesn't know enough to babysit, and he's going to get Kirsty to think the same thing.
   B. Peter: I heard Ed saying that he thinks Haley doesn't know enough to babysit, but he isn't going to tell Kirsty that he thinks that.

5. A. Claire: Do you know what Peter heard the other night? He heard Ed saying that he needs to persuade Kirsty that Haley doesn't know enough to babysit for them!

B. Claire: Did you know that Ed thinks that Haley doesn't know enough to babysit for them, and that he wants to persuade Kirsty that she doesn't know enough? Peter told you - ? I didn't know Peter knew about this. Just wait until he gets home…

6. A. Claire: Peter, we can't really stand up for Haley because it's true, but she'd be devastated if she found out that I knew and hadn't done anything.

Peter: I see, you don't want to upset her further.

Claire: Yeah, she really wouldn't take it well.

B. Claire: Hmm, maybe I should tell her all of this so that she knows why she isn't allowed to babysit.

Peter: But won't she be upset that you're not defending her?

Claire: Nah, she'll be fine.

7. A. Claire: What?! No, we can't tell her! She'd be devastated if she knew that I knew what you'd heard, about Ed being mean enough to plan to convince Kirsty that Haley doesn't know enough to babysit! We must make sure she doesn't find out.

B. Claire: OK, Haley definitely has to know about all of this – you need to go and tell her that you heard Ed planning to tell Kirsty that she's too clueless to babysit.

Peter: Can I tell her that you agree with them?

Claire: Yeah, I think that's a good idea.

Control questions

1. A. Claire: This is Claire; I'm calling about my daughter Haley.

   B. Claire: This is Claire; I'm calling about my niece Haley.

2. A. Haley: Yeah, my mom's got remarried, to this guy called Peter. He's actually pretty cool.

   B. Haley: No, I'm talking about my mom's brother Peter. I really like him.

3. A. Claire: And my daugher Haley has a whole new family – her new stepdad, and his sister Kirsty…

   B. Claire: And my niece Haley has a whole new family – my new husband, and his cousin Kirsty…

4. A. Haley: My mom's new husband is actually pretty cool. He has this awesome sister, and her husband Ed is totally laid back.

   B. Haley: My mom's brother is really cool. His wife has a new stepdad, Ed, who is totally laid back.

5. A. Ed: Yeah, I know, it's so confusing with all the remarriages. So Haley's mom is married to my wife's brother. And Jay is my dad.

   B. Ed: Yeah, I know, it's so confusing with all the remarriages. So Haley's mom is married to my brother, and Jay is my wife's father.

6. A. Anna: …and Haley wants to babysit! Who's Haley? Gosh. Well, you know my husband's son? His wife has a brother who's just married a woman called Claire, and Haley is Claire's daughter.

   B. Anna: …and Haley wants to babysit! Who's Haley? Gosh. Well, you know my brother Jay's daughter? Her husband has a sister, who just married a man called Peter, and Haley is Peter's daughter.

7. A. Haley: Argh, no, get it straight, what kind of boyfriend are you? Martin's my step-aunt-in-law's stepbrother. OK, I'll go slower. I have a step-aunt, because

her brother is my step-dad. Right? So my step-aunt's husband is my step-uncle-in-law. Now his father just re-married, and his new wife has this son Martin, so Martin is my step-uncle-in-law's stepbrother. Get it?

B. Haley: Argh, no, get it straight, what kind of boyfriend are you? Martin's my step-aunt-in-law's cousin. OK, I'll go slower. I have a step-uncle, because his brother is my stepfather. Right? So his wife is my step-aunt-in-law. Now her father has a sister who lives with him, and her son is called Martin. So Martin is my step-aunt-in-law's cousin. Get it?

Story 4: Sheila's Problem

Scene 1: John and Sheila's encounter (office) John hands Sheila a stack of papers and he gets awkward.

John: Oh, um, Sheila, hi, um – nice – um – scarf.

Sheila: Thanks, John. I'll get these back to you by tomorrow.

John: Yup, great, thanks, nice, that would be good.

John exits, Amy enters

Sheila: Oh gosh, Amy, I'm in such an awkward situation.

Amy: Yeah? What's up?

Sheila: Well, you know my supervisor Mike, right? His boss Courtney has this new PA, John, who gets really weird around me. I think he has a crush on me and it's really uncomfortable.

Amy: That's awkward. Are you going to confront him about it?

Sheila: What, are you mad? Poor guy would explode. It would make it a hundred times worse. No, I'll just keep letting him think I have no idea about it.

Amy: Yeah, good idea.

Scene 2: John talks to Tim about Sheila

Tim: Anyway, so how's it going at your new job?

John: Urgh, not so good at the moment. Remember I told you about Sheila, who works in Finance?

Tim: Yeah?

John: Yeah, I've gone full schoolboy crush on her. I blush and get awkward and everything. It's terrible.

Tim: Oh, yikes. Does she know?

John: No, I don't think so. She still acts completely normal around me.

Tim: That's a relief.

John: Yeah. Anyway, I'd better run.

Tim: Cheers, hope the office gets better!

Scene 3: Amy enters

Amy: Hi, sweetheart.

Tim: Hiya.

Amy: So how's John?

Tim: Poor guy, he's in an awkward situation at work. He actually has a schoolboy crush, can you believe it? On someone called Sheila.

Amy: Sheila? Oh, yeah, she told me about it.

Tim: She knows? Aw, John thinks she hasn't realised how he feels. He'd be mortified if he found out that she does know.

Amy: It's all right, her plan is to keep him in the dark – she doesn't want him to know that she's realised, because it'll make it so much more awkward.

Tim: That's all right then.

Amy: But – I wonder if Victor knows about this?

Tim: Victor?

Amy: Victor, you know Victor! My brother Shaun's best friend? He's married to Sheila!

Tim: Oh, yeah, right, Victor.

Amy: He should know about this, even if there's nothing going on. I'll chat to him later.

Scene 4: Amy tells Victor

Amy: Victor, I need to chat to you about something.

Victor: What's up?

Amy: Tim told me something he heard the other day and I thought that, as Sheila's husband, you

deserved to know.

Victor: Oh god, this doesn't sound good.

Amy: It's not a huge deal, it's just that there's somebody at Sheila's office, John, who has a bit of a thing for her, and Sheila's worked it out, but she's pretending not to know to stop things from getting awkward.

Victor: Oh, yeah, she told me about that. Poor guy.

Mental questions

1. A. John: I have a schoolboy crush on Sheila
   B. John: I have a schoolboy crush on Amy
2. A. Sheila: Yeah, it's a bit awkward, John has a crush on me.
   B. Amy: You know that John has a crush on you, right?
   Sheila: What?! I had no idea!
3. A. John: It's all right, Sheila hasn't realised that I like her.
   B. John: Urgh, it's so awkward, I just *know* she's realised that I like her.
4. A. Sheila: He doesn't know that I've figured out that he likes me, and I'm just going to keep it like that.
   B. Sheila: I think I need to confront John and tell him that I know he's into me.
5. A. Amy: It's all right, Sheila's just going to keep acting normally so that John thinks she hasn't realised about his feelings for her.
   B. Amy: Sheila's just going to keep John thinking she hasn't realised about his feelings for her? That's weird, why didn't she tell me?
6. A. Sheila: Anyway, so I chatted to Amy about it at the office and she reckons it's a

good plan to just keep letting John think I haven't figured it out.

Victor: Yeah, Amy came by and told me about it all.

B. Sheila: Anyway, so I chatted to Amy about it at the office and she reckons it's a good plan to just keep letting John think I haven't figured it out.

Victor: That's weird, I spoke to Amy today. I had no idea that she knew about this situation.

7. A. Amy: You know, Victor really needs to know about this. Even if there's nothing going on between Sheila and John, he needs to know that his wife knows someone has a crush on her, and what she's planning to do about it. He'd be really upset if he knew I knew about all of this and didn't tell him. I'd better talk to him.

B. Amy: Hmm, I don't think Victor should know about this. Even if there's nothing going on between John and Sheila, Victor's really jealous and he'd be furious to find out that his wife actually knew someone had a crush on her. He'd also be really angry if he found out that I know. I'd better not tell him.

Control questions

1. A. Sheila: You know my supervisor, Mike?

B. Sheila: You know my PA, Mike?

2. A. Sheila: You know my supervisor's boss, Courtney?

B. Sheila: You know my PA's supervisor, Courtney?

3. A. Sheila: Anyway, my supervisor Mike, his boss has hired this new PA, John.

B. Sheila: Anyway, my PA Mike's boss has this new supervisor, John.

4. A. Amy: Oh, you know Sheila? Well, her supervisor Mike, his boss has this new PA, John.

Tim: My best friend John?

Amy: That's the one.

B. Amy: Oh, you know Sheila? Well, her best friend Mike, his boss has this new PA, John.

Tim: Oh, I'm John's supervisor.

5. A. Victor: How did Amy know about this whole situation?

Sheila: It's a bit complicated. So John is my supervisor Mike's boss's new PA, and John's best friend is Amy's boyfriend.

B. Victor: How did Amy know about this whole situation?

Sheila: It's a bit complicated. So John is my PA Mike's supervisor's boss, and John's best friend is Amy's boyfriend.

6. A. Amy: Yeah, it's really complicated. So your best friend is Sheila's supervisor Mike's boss's PA, John, and Shaun is my brother.

B. Amy: Yeah, it's really complicated. My boyfriend is PA to Sheila's best friend Mike's supervisor's boss, John, and Shaun is my brother.

7. A. Tim: How does everyone know each other again?

Amy: So, your best friend John is Sheila's supervisor Mike's boss's PA. And Sheila is married to my brother's best friend Victor.

B. Tim: How does everyone know each other again?

Amy: So, Sheila's my best friend, and my brother Mike's boss's supervisor, John, has just hired a new PA. Victor is that PA's girlfriend's friend.

Supplementary Information

Breakdown of methodological flaws in IMT questions

The version of the IMT that we analysed includes 5 stories, each of which had 10 mental and 10 control questions associated with it (2 for each level of mindreading tested). Table 1, below, provides a breakdown of the methodological flaws we identified in the IMT (see main text for discussion).

Key. M = mental question; C = control question. For the columns 'Impossible choice', 'Implausible forced choice', and 'Broken conceptual chain', 1 = yes, 0 = no. The 'Syntactic complexity' column gives the number of embedded clauses for each question. These were established using the following rules, which were designed to identify the number of embedded clauses that would need to be processed by a reader in order to understand the sentence:

1. The maximum depth of embedding in each sentence was counted, e.g. "Jim thought that Mary liked Bob" = 1 embedded clause (Mary liked Bob)
2. Clauses that could be omitted from the sentence in order to process it were not counted – e.g. "Jim, who lived in Wiltshire, thought that Mary liked Bob" = 1 embedded clause ("who lived in Wiltshire" not counted, "Mary liked Bob" counted as embedded clause)
3. The main clauses of compound sentences (see 'Broken conceptual chains, above) were treated as separate sentences, e.g. "Bob was eighteen and worked as a milkman" = no embedded clauses ("Bob was eighteen" = main clause; "Bob worked as a milkman" = main clause). If the main clauses of a compound sentence had different levels of embedding, the main clause with the highest level of embedding was treated as representative of the whole sentence.

		M/C	Impossible choice	Implausible false choice	Broken conceptual chains	Syntactic complexity
Story 1	Henry thought that Sam knew he was a prankster	M	1	0	0	2
	Henry knew Sam believed he knew where the Post Office was	M	1	0	0	3
	Sam thought that Henry knew the Post Office was in Bold Street and hence that Henry must have intended to mislead Sam	M	0	0	1	2
	Sam believed that Pete thought the Post Office was in Elm Street and hence that Pete must not have intended to mislead Sam	M	0	0	1	2
	Pete wanted Sam to know that Henry believed that the Post Office was on Elm Street and hence did not intend to mislead him	M	0	0	1	3
	Pete wanted Sam to know that he believed that Henry had intended not to mislead him	M	0	0	0	4
	Henry wanted to play a trick	M	1	0	0	1
	Sam thought Henry knew he wanted a Tax Disk	M	0	0	0	2
	Pete suspected that Henry was playing a prank on Sam	M	0	0	0	1
	Sam wanted to buy a stamp	M	0	1	0	1
	Total/mean mental (story 1):		3	1	3	2.1
	Sam left Bold Street, then went to the office and spoke to Pete	C	0	0	0	0
	Pete, the man who worked at the same place as Henry, and who knew that Henry was the office prankster, was Sam's cousin	C	0	1	0	1
	The Post Office was closed and Sam's insurance had run out	C	0	1	0	0
	Sam found the Post Office closed and couldn't buy a tax disk for Pete	C	0	0	0	0
	Sam asked Henry, and did not ask Pete or the traffic wardens, about where the Post Office was in order to buy a Tax Disk	C	0	0	0	1
	Sam needed a Tax Disc from the office	C	0	0	0	0
	The Post Office was closed because it had moved to Bold St	C	0	0	0	0
	Sam who worked with Pete and Henry did not know where to buy a Tax Disk because he was new to the area	C	0	0	0	0
	Henry, the man that Sam spoke to about where to buy a Tax Disk after he realized he needed to buy one soon, was a colleague of Pete's	C	0	0	0	1
	The Post Office in Elm St. had a notice on the door	C	0	0	0	0
	Total/mean control (story 1):		0	2	0	0.3
	Overall total/mean (story 1):		3	3	3	1.2
Story 2	Penny thinks Pete hopes that Sheila will have a drink with him	M	0	0	0	2
	Penny suspected that John wanted to know whether Penny knew if Sheila would like to go for a drink with him	M	0	0	0	3

	John knew that Pete would understand not being asked for a drink, because Pete knew that John fancied Sheila	M	1	0	1	2
	Sheila was surprised John asked Penny to go for a drink	M	1	0	0	2
	Sheila believed that John knew she was busy so John wanted to ask Penny out alone but didn't want Sheila to feel left out, so John instead said he wanted both women to come	M	1	0	1	2
	Penny knew that John was keen on Sheila, so she suspected that John wanted to find out whether she knew what Sheila might want to do	M	0	0	1	3
	Penny thought that Sheila wouldn't go for a drink with him	M	1	0	0	1
	John knows that Sheila likes aerobics	M	0	0	0	1
	John wanted to go for a drink after work	M	0	0	0	1
	John thought Penny knew what Sheila wanted to do	M	0	0	0	2
	Total/mean mental (story 2):		4	0	3	1.90
	John always asks Penny to go drinking with him and Pete	C	0	0	0	1
	John didn't ask Pete or Sheila to go for a drink	C	0	0	0	1
	Penny usually went for a drink after work	C	1	0	0	0
	Pete worked with Penny and Sheila	C	0	0	0	0
	John wants to go out with Jenny	C	0	1	0	1
	Sheila, who works with John and Penny, goes to an aerobics class every day after work and doesn't usually go drinking	C	0	0	0	0
	Pete, the man that John usually went drinking with after work, was not asked out because John asked Penny and Sheila instead	C	0	0	0	0
	Sheila spoke to Penny but did not speak to Pete or John about giving up her aerobics class because she knew she fancied John	C	1	0	0	1
	John, who fancied Sheila but who asked Penny and Sheila out for a drink, usually went drinking with Pete, but asked the women because he is keen on Penny	C	0	0	0	0
	John didn't ask Pete or Sheila to go drinking after work	C	0	0	0	1
	Total/mean control (story 2):		2	1	0	0.50
	Overall total/mean (story 2):		6	1	3	1.20
Story 3	Emma thought her boss knew the chemist hadn't offered her a job	M	0	0	0	2
	Jenny thought that Emma's boss would believe that Emma would like to work for the chemist who wanted Emma to work for her	M	0	0	0	5
	Jenny thought that Emma's boss would think that the chemist, who allegedly wanted Emma to come and work, thought that Emma should be paid more	M	0	0	1	3
	Jenny wanted Emma to get a raise	M	0	0	0	2
	The chemist knew about Emma's story	M	0	0	0	1
	Emma believed that Jenny hoped that her boss would believe Emma's claim about the chemist wanting to offer her a job	M	0	0	0	4
	Jenny hoped the greengrocer believed the chemist had offered Emma a job	M	0	0	0	2

	Jenny knew that Emma was unhappy with her wages so she believed that if she got Emma's boss to think that the chemist wanted Emma to go and work there, he would believe her	M	0	0	1	3
	Emma's boss believed the chemist wanted to give her a job	M	0	0	0	2
	Jenny thought Emma's boss would believe the story	M	0	0	0	1
	Total/mean mental (story 3):		0	0	2	2.5
	Emma was offered a job at the bank	C	0	1	0	0
	The greengrocer asked Jenny if Emma had been offered a job	C	0	0	0	1
	Jenny went to see the chemist about offering Emma a job	C	0	0	0	1
	Emma worked at a chemist near where she lived	C	0	0	0	1
	Jenny who was Emma's friend and from whom Emma asked advice, was a career girl	C	0	1	0	0
	Emma worked at a greengrocer, her friend Jenny who was still at school worked at the chemist, where Emma lied about wanting to work	C	0	0	0	1
	The greengrocer, who was Emma's boss who paid her a low wage, went to speak to the chemist after he realized that Emma might be lying and discovered that she was	C	0	0	0	3
	Jenny asked the chemist if she had offered Emma a job	C	0	0	0	1
	Emma, who worked at the greengrocer and lived near the chemist, asked Jenny, her friend who was still at school, for advice on what to do about her grades	C	0	1	0	1
	Emma's boss is the greengrocer	C	0	0	0	0
	Total/mean control (story 3):		0	3	0	0.9
	Overall total/mean (story 3):		0	3	2	1.7
Story 4	Simon knew that Jim thought that Simon found Edward more socially appealing, and that Susan thought Jim was boring	M	0	0	1	2
	Simon wants Jim to believe that Edward fancies Betty	M	0	0	0	2
	Jim wants to marry Susan	M	0	0	0	1
	Simon wants to take Jim out for a drink	M	0	0	0	1
	Simon imagined that Betty wanted to marry Edward but that Edward really wanted to marry Susan, whom Jim would like to have married	M	0	0	1	1
	Simon hoped that Jim would believe that Edward wanted to marry Betty because Simon wanted to make Jim happy by thinking he had a chance with Susan	M	0	0	1	2
	Jim believes Susan thought that Edward works as a milkman	M	0	0	0	2
	Simon wanted Jim to know that Susan thought that he wanted to marry her and that she would like to marry him also	M	0	0	1	3
	Simon knows his cousin wants to marry Susan	M	0	0	0	1
	Jim thinks that Susan wants to marry Edward	M	0	0	0	1
	Total/mean mental (story 4):		0	0	4	1.6
	Edward went to primary school with Simon's cousin, Jim	C	0	0	0	0

	Jim's cousin is 20 years old	C	0	0	0	0
	Jim and Edward have been friends since school	C	0	0	0	0
	Jim is Simon's cousin and often goes out with Susan	C	0	0	0	0
	Edward, who was a friend of Jim's worked at a bank, and had time to go out at night, unlike Jim who worked as a milkman and couldn't socialize at night because of his hours	C	0	0	0	0
	Simon is Jim's cousin and is a mechanic	C	0	0	0	0
	Jim, who is Simon's cousin and Edward's friend, doesn't have much of a social life because he works as a milkman and doesn't get out in the evenings	C	0	0	0	0
	Edward, who works in a bank and has plenty of spare time, was friends with Jim but didn't know Betty or Susan	C	0	0	0	0
	Jim is older than Simon and is a banker	C	0	0	0	0
	Simon, who was Jim's brother and who worked as a mechanic, was 19 yrs old, which was a lot younger than Jim who worked as a milkman, and didn't socialize much	C	0	0	0	2
	Total/mean control (story 4):		0	0	0	0.2
	Overall total/mean (story 4):		0	0	4	0.9
Story 5	Clive understood that Lucy knew that Clive regretted that Lucy was feeling angry because Clive did not know what to eat	M	0	0	0	4
	Clive wanted Lucy to know that Clive thought that Lucy understood that he didn't like seafood	M	0	0	0	4
	Clive thought Lucy was upset because he didn't like seafood	M	0	0	1	2
	Lucy was worried that Clive believed she didn't like the restaurant	M	0	0	0	2
	Clive wanted a vegetarian option	M	0	0	0	0
	Lucy wanted Clive to know that Lucy thought that Clive believed the restaurant was too expensive	M	0	0	0	4
	Clive thought that Lucy believed that Clive knew that Lucy thought that Clive felt that the food was too expensive	M	0	0	0	5
	Lucy thought Clive was worried about the price	M	0	0	0	1
	Lucy knew Clive had remembered their anniversary	M	0	0	0	1
	Lucy thought the food was too rich	M	0	0	0	1
	Total/mean mental (story 5):		0	0	1	2.4
	Lucy ordered monkfish and chips	C	0	0	0	0
	The expensive restaurant that Clive booked only sold seafood	C	0	0	0	1
	Clive booked a restaurant to celebrate their 2nd wedding anniversary	C	0	0	0	1
	When the waiter came to the table, Lucy had made up her mind and ordered the monkfish and salad; Clive had not yet decided	C	0	0	0	1
	The vegetarian restaurant overlooked the harbour	C	0	0	0	0
	While having lunch at a seafood restaurant, Clive perused the menu for a vegetarian option while Lucy ordered the monkfish and salad	C	0	0	0	1

	Lucy ordered the monkfish and salad, Clive ordered nothing	C	0	0	0	0
	Clive and Lucy sat at a table beside the window which overlooked the harbour; there was a candle in a wine bottle sitting on their table	C	0	0	0	1
	The table was beside a window and overlooked the harbour, it had a deep red tablecloth and a candle in a wine bottle	C	0	0	0	0
	Clive booked a restaurant to celebrate their anniversary	C	0	0	0	1
	Total/mean control (story 5):		0	0	0	0.6
	Overall total/mean (story 5):		0	0	1	1.5
Total/mean mental:			7	1	13	1.62
Total/mean control:			2	6	0	0.50
Overall total/mean:			9	7	13	1.06