Something to talk about: Conversation sizes are constrained by mental modeling abilities

Jaimie Arona Krems, Robin I. M. Dunbar, and Steven L. Neuberg

Author Note

Jaimie Arona Krems, Steven L. Neuberg,
Department of Psychology, Arizona State University, Arizona State University, Tempe, AZ 85287-1104. jaimie.krems@asu.edu; steven.neuberg@asu.edu

Robin I. M. Dunbar
Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford, UK, OX1 3UD, robin.dunbar@psy.ox.ac.uk.

Correspondence concerning this article should be addressed to Jaimie Arona Krems, Department of Psychology, 950 S. McAllister St., Arizona State University, Tempe, AZ 85287- 1104. Email: jaimie.krems@asu.edu.

Competing Interests
We have no competing interests.

Authors' Contributions
Krems and Dunbar conceived of the hypotheses. Krems, Dunbar, and Neuberg conceived of the study designs and supervised data collection. Krems completed data analyses under the auspices of Neuberg. Krems drafted the manuscript under the auspices of Dunbar and Neuberg. All authors gave final approval for publication.

Acknowledgments
RD's research is funded by a European Research Council Advanced grant (295663). We thank Alexander Danvers and Sean C. Murphy for their helpful comments on an earlier version of this work

Abstract

Conversations are ubiquitous and central elements of daily life. Yet a fundamental feature of conversation remains a mystery: It is genuinely difficult to maintain an everyday conversation with more than four speakers. Why? We introduce a "mentalising explanation" for the conversation size constraint, which suggests that humans have a natural limit on their ability to model the minds of others, and that this limit, in turn, shapes the sizes of everyday conversations. If an mentalising explanation is correct, then conversations that require the mental modeling of an absent party (e.g., gossip) should contain, on average, one person fewer (three) than other types of conversations (four). In line with established methodologies, we investigate and find support for this prediction both in naturally-occurring, real-world conversations and in those drawn from Shakespearean plays. Our results support a mentalising explanation for the conversation size constraint and also render alternative accounts less plausible.

Keywords: communication, group size, language, theory of mind, mentalising

Something to talk about: Conversation sizes are constrained by mental modeling abilities

"Each person's life is lived as a series of conversations."

- Deborah Tannen (1991, p. 13)

Conversation wears many hats. Conversation enables strangers to engage in everyday cooperative acts—from business transactions to building social relationships. Conversation is a means by which current friends and sweethearts come to truly know one another. And conversation is how vital and banal information flows from one person to others. Yet, as any dinner party host knows, a conversation with more than a handful of speakers is hard to sustain.

Multiple studies affirm this: Everyday conversations, as opposed to lectures or formal discussions, rarely exceed four participants (one speaker and three listeners; Dezecache & Dunbar, 2013; Dunbar, 2009; Dunbar, Duncan, & Nettle, 1995). With the addition of a fifth participant, or more, one conversation typically fissions into two. Indeed, this real-world effect is so robust that dramatists mirror it in fiction: Across Shakespearean plays, modern "hyperlink" films, and even British soap operas, the average number of speakers per scene does not exceed four (Krems & Dunbar, 2013; Matthews & Barrett, 2005; Stiller, Nettle, & Dunbar, 2003).

If everyday conversations are how we cooperate, connect, and ultimately communicate with one another, then why are we typically limited to conversing with no more than three other people at a time? Two alternative hypotheses have been suggested—that the constraint is set by the number of minds a speaker has to model (the mentalising hypothesis; Krems & Dunbar, 2013) or by the effect that the physical spacing of speakers has on speech detectability (the speech detectability hypothesis; Cohen, 1971; Sommer, 1971; Webster, 1985). A third

possibility, not explored in the literature, is that the size of a conversation is limited by the mind's capacity for information processing (the 'magical number' 4±1; Cowan, 2001).

Mentalising Constraints

The familiar term "Theory of Mind" (ToM) refers to the capacity to understand another person's mind state (i.e., to mentally model another's wants, beliefs, etc.). In the sentence "Bettina understood that Eliott wanted to play tennis," Bettina is modeling Eliott's mind. If Bettina is exhibiting ToM, then what is the reader doing when comprehending that Bettina understands what Eliott wants? ToM is one 'level' of the larger capacity for mentalising. When exhibiting ToM, Bettina is mentalising at second-order intentionality, but when comprehending that Bettina understands what Eliott wants, the reader is mentalising at third-order intentionality, and so on. Intentionality thus forms a naturally-recursive hierarchy of increasingly embedded mindreading (e.g., We *know* that you *comprehended* that Bettina *understood* that Eliott *wanted*…).

Almost all human adults can comfortably work at fourth-order intentionality, and many can ably manage fifth-order (Kinderman, Dunbar, & Bentall, 1998; Stiller & Dunbar, 2007; Powell, Lewis, Dunbar, Garcia-Fiñana, & Roberts, 2010). But only about 20 percent of people can cope above fifth-order intentionality (Kinderman et al., 1998; Stiller & Dunbar, 2007). For most, the multiple layers of thoughts, beliefs, and desires simply become too difficult to follow. Similarly, there may be limits on the number of other individual minds one can model at any one time. For example, Bettina might be able to keep straight what Eliott thinks of her, what a second person thinks of her, and what a third person thinks of her, and so on, but each additional instance of second-order mentalising might be increasingly difficult to simultaneously manage.

Different conversations require different management capabilities (i.e., different amounts

of mentalising resources). For instance, a parent lecturing a teenager poses low demands: the parent has to model only the teenager's mind (second-order intentionality), and the teenager has to model only the parent's mind. By contrast, larger conversations may require one to model the minds of more speakers, thus requiring higher levels of competency for successful communication (e.g., Dunbar, 2009; Zunshine, 2006). At the famed Camp David political summit in 2000, for instance, it may have served U.S. President Bill Clinton to know both what Israeli Prime Minister Ehud Barak and what Palestinian Authority Chairman Yasser Arafat thought about him, but it was perhaps even more useful for Clinton to know what Barak thought that Arafat wanted. In this three-person conversation, then, Middle Eastern peace negotiations required at least third-order intentionality.

A mentalising explanation. As mentalising competency is limited in most adults, the mentalising hypothesis predicts that most conversations will be respectful of this specific limit. Concretely, as it becomes difficult to follow a conversation above fourth-order intentionality (one speaker modeling three other minds), most conversations should not exceed a four-person limit. And the addition of a fifth person may put pressure on the growing conversation to fragment into smaller, mentally-manageable conversations.

This specific prediction accords with the previous literature: everyday conversations do seem to have a four-person limit (Dunbar et al., 1995; Krems & Dunbar, 2013; Matthews & Barrett, 2005; Stiller et al., 2003). Moreover, the putative link between mentalising capacity and conversation size is further bolstered by evidence demonstrating (a) links between individual children's mentalising capacities and the sizes of their respective play groups (Henzi et al., 2007) and (b) links between individual adult's mentalising capacities and the sizes of their respective core friendship groups (Stiller & Dunbar, 2007). However, alternative explanations may also be

able to account for this four-person limit.

Alternative hypotheses for the conversation size constraint. According to the speech detectability hypothesis, as the physical size of the conversation circle increases, it gets more difficult for those involved in the conversation to hear one another (Cohen, 1971; Sommer, 1971; Webster, 1985). On this view, auditory constraints are responsible for the limits on conversation size. Although not posited in the literature, a factual working memory account might also explain the limits on conversation size. On this view, factual working memory is limited in the number of chunks of information (e.g., numbers) that a person can manage at any one time (4±1; Cowan, 2001). Whereas it may be stretching the context somewhat, applying this limit to conversations might also suggest that conversations sizes would not typically exceed four speakers.

The Present Work

A mentalising explanation and these alternative explanations could each conceivably account for the robust limit on conversation size. Thus we here derive and test a second prediction from the logic of the mentalising explanation for the conversation size constraint. In doing so, we are able to distinguish among these alternative accounts for the robust limit on conversation size.

Mentalising capacity might constrain conversation size in a second way—via conversational content. According to the mentalising hypothesis, everyday conversations might call on a speaker to model the minds of fellow conversationalists (e.g., what they think, what they believe other speakers think), but some conversations might further ask a speaker to model the mind of someone named in—but, importantly, not physically present in—the conversation. For example, the sentence “Bill Clinton knew he had a tough negotiation on his hands” asks the listener to model Clinton’s mind. If the mentalising hypothesis is correct in proposing that

mentalising competency constrains conversation size, then talking about an absent party (in this case, Clinton) in a way that requires mentalising will further restrict conversation size. That is, modeling the mind of a person not physically present in the conversation will eat up "a unit" of mentalising that can no longer be spent on another fellow speaker. Thus, when speakers are discussing the thoughts, beliefs, or desires of an absent party, the conversation size should drop from its conventional average maximum of *four* to *three*.

This prediction is unique to the mentalising hypothesis and would allow us to test between it and the alternatives. The speech detectability hypothesis would not expect an influence of conversational content on conversation size. On the surface, a factual working memory account might make a similar prediction, as the absent party's mind is another chunk of information to manage. However, we can easily distinguish between the social (i.e., mentalising) and factual capacity accounts: according to a mentalising account, speakers' mentalising resources are only expended when modeling the mind of an absent party, but not when discussing an absent party in such a way that does not call on mentalising abilities (e.g., purely factual speech, such as "Clinton was a memorable President"). A working memory account would not make a distinction as to how speakers discuss an absent party.

Study 1

We tested the mentalising explanation for the conversation size constraint against the two alternatives in freely-formed conversations observed in a natural environment (public areas on a college campus). It is this type of everyday communication that previous investigation has found to be limited to four speakers (e.g., Dezecache & Dunbar, 2013; Dunbar, 2009; Dunbar et al., 1995). Whereas other types of conversations (e.g., lectures, juries, business management meetings) also allow for the transmission of important information, they may have additional

functions (e.g., the execution of specific plans) and/or structural constraints (e.g., formal, steeply hierarchical) that place different requirements on conversation size. Our prediction relates not to those conversations, but rather to everyday, natural conversations that are generally loosely structured and not beholden to specific task constraints—that is, to the majority of conversations people have each day. Thus, we focus our investigation on freely-formed conversation groups and ask whether the number of people involved in these conversations varies systematically with the topic of the conversation.

Methods

Building on previously established methodology (Dunbar et al., 1995), freely-formed conversation groups of two or more (N = 175) occupying public areas on a large university campus were identified and were approached by pairs of research assistants (who were blinded to the hypotheses). After ascertaining from afar the conversation group size, defined as those individuals involved in conversation (i.e., those speaking and those paying close attention to the speaker[s]), research assistants attained participant consent. Research assistants then asked those groups wherein all participants affirmed consent to recount the most recent verbal exchange as close to word-for-word as possible. Only data from those conversation groups in which all participants gave consent was used. This methodology was approved by the Arizona State University Institutional Review Board.

The reported content of the conversation was then used by the two research assistants, independently, to classify the conversation**.** Conversations were classified as: *mentalising* (exchanges requiring speakers to model the mind of an absent party, e.g., "Vera wanted to study for that test"), *absent party* (exchanges dealing with at least one absent party in such a way that did not require mental modeling, e.g., "Vera aced that test"), *non-absent party* (exchanges not

dealing with absent parties, e.g., "You're looking well today"). Research assistants agreed on 88% percent of the cases. The 24 cases where the research assistants disagreed were dropped from the analysis.

Results and Discussion

Figure 1a plots the mean (±se) number of people involved in conversations of the three mutually exclusive types. A one-way analysis of variance (ANOVA) revealed a significant difference in group sizes across these conversation types: $F(2, 172) = 7.30$, $p = .001$, partial $\eta^2 = .08$. The number of speakers in mentalising conversations ($M = 2.34$, $SE = 0.20$) was less than the number of speakers in both absent party conversations ($M = 3.06$, $SE = 0.19$; $p < .001$, partial $\eta^2 = .08$) and non-absent party conversations ($M = 3.43$, $SE = 0.21$; $p = .011$, partial $\eta^2 = .04$). The number of speakers in those categories wherein conversations did not require mentalising about an absent party (absent party and non-absent party) was indistinguishable ($p = .195$). These results are in line with the predictions of the mentalising hypothesis.

Moreover, when required to model the mind of an absent party, the conversation size was approximately one person smaller (0.89 persons) than when modeling an absent party's mind was not required, going from an average upper limit of just under four people in "non-mentalising" conversations (i.e., absent part and non-absent party types) to one of just under three people in "mentalising" conversations. Both the upper limits for different conversation types found here (three and four persons) as well as the approximately one-person difference between the mentalising and non-mentalising conversation types also support our prediction. Moreover, the actual range of mentalising conversations was between two and four speakers—indeed, 90% of mentalising conversations had only two or three speakers—meaning that

participants did not have to work above the comfortable limits of intentionality (e.g., Kinderman et al., 1998).

Taken together, these findings seem to support the prediction made by the mentalising hypothesis (Krems & Dunbar, 2013) and are broadly incompatible with either the speech detection or the factual working memory explanations, neither of which would have predicted these differences in conversation group size.

Study 2

Study 2 attempts a replication of our findings in 'conversations' from a different time and place: Elizabethan England. Shakespeare's plays are read the world over. They are renowned for their long-standing commercial success as well as their outstanding ability to mirror many real-world conversational conventions (Hutton, 1982). Although love and intrigue are common to any epoch, Shakespeare's stage is, of course, a far cry from today's college campuses. Thus, investigating our prediction within Shakespeare's plays constitutes a complementary test of our prediction that natural limits on mentalising abilities shape conversation sizes. Further, analyses of Shakespearean works have played a major role in research uncovering the conversation size constraint (e.g., Stiller et al., 2003; Stiller & Husdon, 2005). Therefore, if we observe the same pattern of conversation sizes in Shakespearean plays (Study 2) as we did in natural conversations (Study 1), this would further bolster a mentalising explanation.

Method

We tested our predictions using 10 plays: *A Midsummer Night's Dream*, *Antony and Cleopatra*, *Hamlet*, *King Lear*, *Othello*, *Richard II*, *Richard III*, *Romeo and Juliet*, *The Taming of the Shrew*, and *The Tempest*. These are the same set of plays used by Stiller et al. (2003) to establish scene sizes in Shakespeare's plays. These plays span the three conventional categories

(histories, comedies, and tragedies), and all versions were taken from the same public site (Hylton; n.d.).

Plays were analyzed using established methodology (Barabasi et al., 2002; Dunne, Williams, & Martinez, 2002; Watts & Strogatz, 1998; Williams et al., 2002) adapted from Stiller et al. (2003). Raters ascertained conversation group sizes by dividing each play into "scene slices." A new scene slice began when a speaking character entered or exited the scene or when the scene changed, as indicated by clear stage directions written into the script (e.g., "*Othello enters"*). For each scene slice, the type of conversation was identified as *mentalising*, *absent-party*, or *non-absent-party*, as in Study 1. The conversation size (the number of speaking characters per scene slice) was determined for each scene slice. If at any point in the scene slice characters modeled the mind of another character not present in the scene, the conversation was classified as "mentalising." If at any point in the scene slice the characters talked about an absent party (but not in a way requiring mental modeling of that absent party), the conversation was categorized as "absent party." If characters did not talk about an absent party in any way, the conversation was classified as "non-absent party."

Classifications were made by ten trained raters. Each rater was assigned one play to score, and also scored one Act (approximately 20%) of a second play for reliability. Raters agreed on 89% percent of these overlapping scenes, which we deemed sufficient to allow scores from all scenes to be used.

Results and Discussion

Results for the ten plays replicated our findings from Study 1 (Figure 1b). A one-way ANOVA yielded a significant difference in the number of speakers per group across conversation types: $F(2, 691) = 18.99$, $p < .001$, partial $\eta^2 = .05$. In Shakespearean plays, the

number of speakers in mentalising conversations (M = 2.32, SE = 0.15) was again fewer than the number of speakers in both absent-party conversations (M = 3.34, SE = 0.16; $p < .001$, partial $\eta^2 = .03$) and non-absent-party conversations (M = 3.51, SE = 0.15; $p < .001$, partial $\eta^2 = .04$). The number of speakers in those non-mentalising conversations was indistinguishable ($p = .460$).

Once again, the magnitude of the differences was as predicted by the mentalising hypothesis (Krems & Dunbar, 2013): when required to model the mind of an absent party, conversation size was approximately one character smaller (1.11 characters) than when mentalising was not required, going from an upper limit just short of four characters in non-mentalising conversations to one just short of three characters in mentalising conversations. This mean limit of three characters in mentalising conversations also supports our prediction. No mentalising conversation involved more than five characters—indeed 90% of mentalising conversations had only two or three speakers, thus requiring readers to work at commonly comfortable levels of intentionality (third- and fourth-order).

In sum, as with the findings of Study 1, conversation sizes in Shakespeare's plays seem dependent on the topic of conversation, again implicating mentalising abilities as the limiting factor.

General Discussion

In both real life and the narrative arts, everyday conversations seem limited to about four people (Dunbar et al., 1995; Krems & Dunbar, 2013; Stiller et al., 2003). In two studies, we investigated—and found support for—a mentalising explanation for the limit on conversation size. In the real-world conversations of college students and in the universally popular works of Shakespeare, natural limits on human mentalising abilities seem to shape conversation size. Most adults can work comfortably at fourth-order intentionality (i.e., in a four-person conversation),

but modeling the mind of an absent party eats up the mental resources that could otherwise have been expended on another speaker: As predicted by a mentalising account, conversations that require one to model the mind of an absent party have an average upper limit of three members, one person fewer than the average four-person upper limit of non-mentalising conversations.

Importantly, these results allow us to exclude a number of possible alternative explanations. The speech detectability hypothesis does not predict that conversation size will differ as a function of conversational topic. Similarly, a factual working memory account should see an absent party simply as a chunk of information, regardless of what mental resources (i.e., social or factual) one calls on to manage that chunk. Our findings thus render these notions less plausible explanations for the constraint on conversation sizes.

Another alternative, also not previously discussed in the literature, is that gossipy conversations (i.e., those particularly about the mental state of an absent party) might require special privacy, necessitating a smaller conversation circle. Consider someone gossiping about the desires of a friend in a real-world setting. The speaker might choose to relay this content to only a few others (i.e., smaller conversation group); the larger this conversation size, perhaps the more danger of it getting out that this speaker discussed the private thoughts of a friend, which could cause reputational damage or impair the friendship. Likewise, gossip about an absent party might only be of interest to an audience that is already familiar with the person being discussed; an adept conversationalist would not burden his audience with information that is neither useful nor interesting to them. Thus, in either case, conversationalists may seek smaller, more private groups to discuss the intentions, desires, or other mental states of absent others. Hence, social sensitivity might be responsible for the relatively smaller sizes of mentalising conversations.

This account depends on concerns about gossipy conversation being exclusive to gossip about an absent party's mental states. However, 'factual gossip' about an absent party (e.g., "Bill Clinton lost weight") has the potential to be just as damning to the gossiper as does discussing an absent party's mental state. Similarly, factual gossip about an absent party may be just as abstruse or uninteresting to those unfamiliar with the person being discussed as mentalising gossip would be (e.g., the sentence "Joachim Gauck lost weight" might be of use or interest only to someone familiar with German politics). Thus, if concerns about the potential costs of gossip were constraining conversation sizes, we might expect that conversations in which speakers discussed an absent party—regardless of whether the absent party was discussed in a mentalising versus a factual way—would be smaller than conversations in which speakers did not discuss an absent party. Yet this was not the case in either real-world conversations or in those from Shakespearean plays; across both samples, only mentalising conversations consistently contained fewer speakers. Nevertheless, our present data cannot definitively rule out this social sensitivity explanation for the conversation size constraint. Doing so may be a fruitful avenue for future, experimental research on conversation sizes.

The notion that natural limits on human social mental capacities may shape conversations accords with both cutting-edge work on prosociality (e.g., De Freitas, Thomas, DeScioli, & Pinker, 2015) and longstanding anthropological and developmental work on natural social group sizes (e.g., Dunbar, 1998; Zhou et al., 2005). For instance, De Freitas and colleagues (2015) find that peoples' decisions to help bystanders are closely linked to their mentalising abilities. Additionally, Dunbar and Stiller (2007) found that social (but not factual) working memory capacity predicted the size of adults' core friendship groups. Henzi and colleagues (2007) later demonstrated a similar link between children's mentalising abilities and the number of peers in

an active playgroup. If the mentalising account is correct, then we might expect a comparable link between adult mentalising abilities and the typical sizes of their conversation groups.

An implication of this idea is that conversations might be most easily sustained when their members have similar mentalising abilities; stretch a participant too far, and he or she might leave the circle. If conversations are a primary means by which people form relationships with one another, and longer-running conversations are typically held with equally-capable mentalizers, the impact of mentalising abilities on conversations might be one possible mechanism underlying assortative friendship. Intriguingly, the average upper limit of conversation size is the same average upper limit of the size of one's primary network (Roberts et al., 2014; Sutcliffe et al., 2012).

A second implication of a link between mentalising and conversation size is that those with lower mentalising competencies may not be able to socialize 'up' as easily as adept mentalizers can socialize 'down.' Lesser mentalizers may therefore have fewer opportunities to form relationships with those who are particularly socially savvy and successful. However, if reading fiction exercises these 'mental muscles' (Kidd & Castano, 2013), there could be major practical benefits to maintaining an emphasis on reading fiction in schooling, as well as on other educational efforts aimed at increasing mentalising competencies (e.g., Santiesteban et al., 2012); doing so could open up more avenues to fruitful friendships, business relationships, and other cooperative bonds between people.

References

Barabâsi, A. L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., & Vicsek, T. (2002). Evolution of the social network of scientific collaborations. *Physica A: Statistical Mechanics and Its Applications, 311,* 590-614.

Cowan, N. (2001). "The magical number 4 in short-term memory: A reconsideration of mental storage capacity." *Behavioral and Brain Sciences,* 24, 87–114.

De Freitas, J., Thomas, K. A., DeScioli, P. D., & Pinker, S. (May, 2015). *The strategic bystander: Theory of mind and common knowledge in decision to help*. Paper presented at the meeting of the Human Behavior and Evolution Society, Columbia, MO.

Dezecache, G. & Dunbar, R. I. M. (2013). Sharing the joke: the size of natural laughter groups. *Evolution and Human Behavior,* 33, 775-779.

Dunbar, R. I. M. (2009). Why only humans have language. In R. Botha and C. Knight (eds.) *The Prehistory of Language* (pp. 12-35). Oxford: Oxford University Press.

Dunbar, R. I. M., Duncan, N. D. C., & Nettle, D. (1995). Size and structure of freely forming conversational groups. *Human Nature, 6,* 67-78.

Dunbar, R. I. M. (1998). The social brain hypothesis. *Evolutionary Anthropology, 6,* 178-190.

Dunne, J. A., Williams, R. J., & Martinez, N. D. (2002). Network structure and biodiversity loss in food webs: robustness increases with connectance. *Ecology Letters, 5,* 558-567.

Henzi, P. S., de Sousa Pereira, L., Hawker-Bond, D., Stiller, J., Dunbar, R.I.M., & Barrett, L. (2007). Look who's talking: developmental trends in the size of conversational cliques,

Evolution and Human Behavior 28, 66-74.

Hutton, J. (1982). *Aristotle's Poetics*. New York: WW Norton and Company.

Hylton, J. (n.d.) Last retrieved September 3, 2013 from The Complete Moby™ Shakespeare: http://shakespeare.mit.edu.

Kinderman, P., Dunbar, R.I.M. & Bentall, R.P. (1998). Theory-of-mind deficits and causal attributions. *British Journal of Psychology*, 89, 191-204.

Krems, Jaimie Arona, & Dunbar, R. I. M. (2013). Clique size and Network Characteristics in Hyperlink Cinema: Constraints of evolved psychology. *Human Nature, 24*, 414-429.

Matthews, P., & Barrett, L. (2005). Small-Screen Social Groups: Soap Operas and Social Networks. *Journal of Cultural and Evolutionary Psychology, 3*, 75-86.

Powell, J., Lewis, P. A., Roberts, N., García-Fiñana, M. & Dunbar, R. I, M. (2012). Orbital prefrontal cortex volume predicts social network size: an imaging study of individual differences in humans. *Proceedings of the Royal Society, London*, 279B, 2157-2162.

Roberts, S. B. G., Arrow, H., Lehmann, J. & Dunbar, R. I. M. (2014). Close social relationships: an evolutionary perspective. In: R. I. M. Dunbar, C. Gamble, and J. A. J. Gowlett (Eds) *Lucy to language: The benchmark papers*, pp. 151-180. Oxford: Oxford University Press.

Santiesteban, I., White, S., Cook, J., Gilbert, S. J., Heyes, C., & Bird, G. (2012). Training social cognition: from imitation to theory of mind. *Cognition, 122*, 228-235.

Stiller, J., & Dunbar, R. I. M. (2007). Perspective-taking and memory capacity predict social

network size. *Social Networks, 29*, 93-104.

Stiller, J., & Hudson, M. (2005). Weak links and scene cliques within the small world of Shakespeare. *Journal of Cultural and Evolutionary Psychology, 3*, 57-73.

Stiller, J., Nettle, D., & Dunbar, R. I. M. (2003). The small world of Shakespeare's plays. *Human Nature, 14*, 397-408.

Sutcliffe, A.J., Dunbar, R. I. M., Binder, J. & Arrow, H. (2012). Relationships and the social brain: integrating psychological and evolutionary perspectives. *British Journal of Psychology*, *103*, 149-168.

Tannen, D. (1991). *You Just Don't Understand: Men and Women in Conversation. London:* Virago.

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world' networks. *Nature, 393*, 440-442.

Williams, R. J., Berlow, E. L., Dunne, J. A., Barabási, A. L., & Martinez, N. D. (2002). Two degrees of separation in complex food webs. *Proceedings of the National Academy of Sciences, 99*, 12913.

Zhou, W., Sornette, D. Hill, R. A., & Dunbar, R. I. M. (2005). Discrete hierarchical organization of social group sizes. *Proceedings of the Royal Society of London, 272B*, 439-444.

Zunshine, L. (2006). *Why we read fiction: Theory of mind and the novel*. Columbus: Ohio State University Press.

.

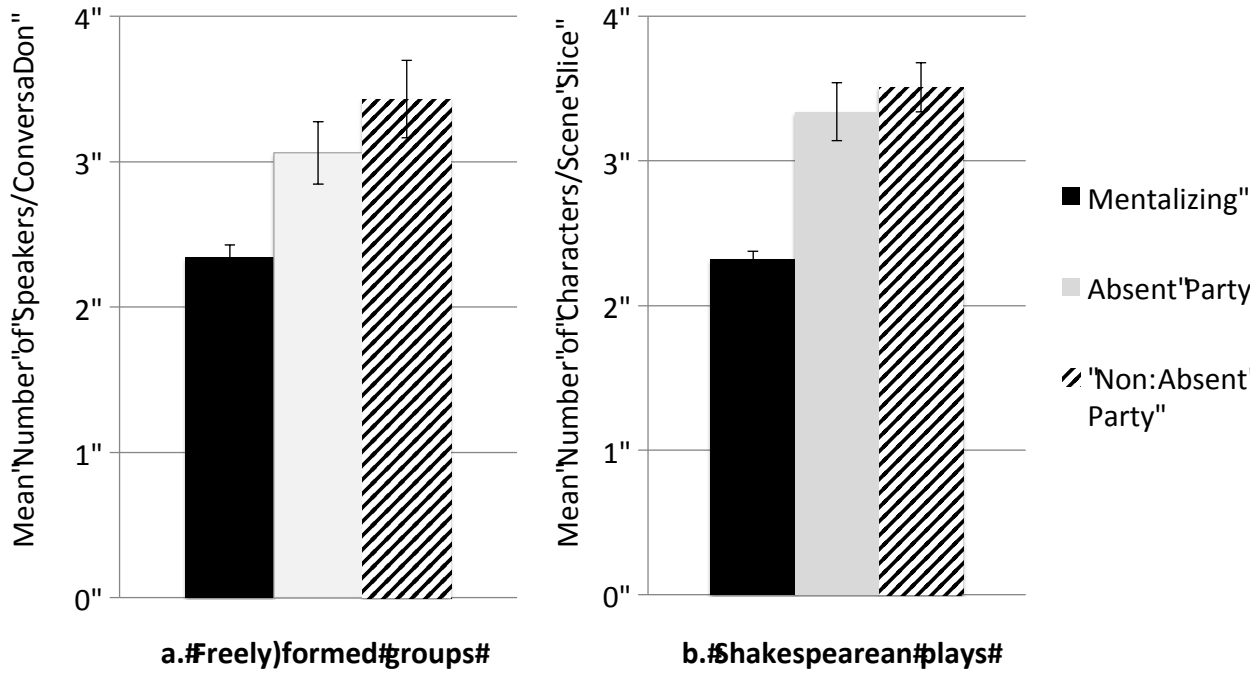

Figure 1. The mean conversation size for the three different types of exchanges in (a) 175 freely-formed groups (Study 1), and in (b) 10 Shakespearean plays (Study 2). Error bars represent standard errors.