Familiarity Modulates the Dynamics of Collaborative Inhibition in a Trivia Game

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Abstract

A number of open questions are still unanswered about whether and how dyads perform better compared to individuals on memory tasks. The literature on collaborative recall demonstrates a robust collaborative inhibition effect, where participants do worse when remembering in collaborative contexts. However, a growing body of research suggests that this inhibition can be ameliorated, or even reversed, under certain task and social conditions. Here we construct nominal groups (hypothetically optimal aggregates of individual performers) to compare to collaborative groups. We observe collaborative inhibition on two performance metrics (number of trivia clues answered, speed of answering), but we find a *facilitatory* effect of collaboration on two other performance metrics (accuracy, number of clues subsequently recalled). We also show that familiarity can reduce this collaborative inhibition in many ways.

Keywords: Collaborative Cognition; Collaborative Memory; Collaborative Recall; Coordinative Structures; Transactive Memory Systems; Joint Action

Introduction

In knowledge-based, joint-action tasks such as working on crossword puzzles or playing team trivia games, success depends not only on the knowledge of each individual, but the way that this knowledge is transferred, synthesized, and generated at the interactive, group level. The current paper uses a trivia task to allow us to connect the well-established work on collaborative memory (and specifically, the collaborative recall paradigm) with the emerging joint-action literature. The collaborative recall paradigm is one of the most frequently used methods of studying collaborative memory. In this paradigm, participants are asked to reproduce a known or learned list of items, either individually or in collaborative groups. Although the overall group product is often higher than the product of controlled individual participants, it almost always fails to outperform the nominal group product, consisting of the pooled, non-overlapping (i.e., a hypothetic, optimal combination of) items recalled by individuals (Barnier, Sutton, Harris, & Wilson, 2008). That is, at the individual level, people remember better when working alone, and don't perform at their full potential during collaboration. This robust finding is known as *collaborative inhibition*, and is thought to result from participants' disruption of each others' unique retrieval strategies during recall (Basden, Basden, Bryner, & III, 1997). Collaborative inhibition has been observed in a number of studies, many of which give specific support to the retrieval disruption hypothesis (for a review, see Rajaram & Pereira-Pasarin, 2010).

An innovative study by Meade, Nokes, and Morrow (2009) challenged the ubiquity of collaborative inhibition. Memory for previously studied flight scenarios was tested for groups composed of expert pilots, novice pilots, or non-pilots. While novices and non-pilots exhibited the standard collaborative inhibition effect, expert pilots did not. In fact, the experts exhibited *collaborative facilitation*–they were better at remembering together than remembering alone. Meade and colleagues (2009) note that these results are consistent with the retrieval disruption hypothesis, in that experts have similar training and knowledge that allows them, presumably, to encode and retrieve information similarly (or, at least, *non-disruptively*). Harris and colleagues (2010), however, note that these results provide empirical justification for the *transactive memory* (TM) *systems* approach (cf. Wegner, 1987).

In TM systems, groups of individuals share the burden of remembering. Although some information is stored only within the individuals, through communication a successful group can share and combine information, resulting in group-level knowledge that exceeds that of any of its individual members. In some cases, the pieces of information held by individual group members can be combined into knowledge that none of the members individually possessed, and in this sense, the whole can truly come to be more than the sum of its parts. According to Wegner, Erber, and Raymond (1991), these emergent memory systems are more likely to succeed when group members are familiar with each other (as expertise and role within the group are already known and can be exploited). Harris et al. (2010; and see Harris, Keil, Sutton, Barnier, & McIlwain, 2011) found evidence for this kind of TM system in their study of couples who had been married for over 20 years. Many of these couples were able to demonstrate collaborative facilitation, but the pattern of results was complex: facilitation was not stable across couples, tasks, nor across within-task topics. Similarly, Hollingshead (1998) found that couples were more likely to form TM systems, but only under certain communication and task conditions.

A successful TM system can be conceptualized as a special case of the more general *coordinative structure* framework described by Shockley, Richardson, and Dale (2009). A coordinative structure is a self-organized, softly assembled (i.e. temporary), set of components that emerges naturally, under certain conditions, and behaves as a single unit (see also Bernstein, 1967). The domain of joint-action is ripe with examples of how people coordinate to move together, either in service of a shared goal (Richardson, Marsh, & Baron, 2007), or even unintentionally (Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007; and see Marsh, Richardson, & Schmidt, 2009). Tollefsen and Dale (2012) point out that when individuals are engaged in a joint task or joint action, they become aligned at multiple levels, including body posture (Shockley, Santana, & Fowler, 2003), linguistic form choice (Pickering & Garrod, 2004), and higher-level cognitive states (Tollefsen & Dale, 2012; Sebanz, Bekkering, & Knoblich, 2006) and alignment at any of these levels can "percolate" up to others. Ultimately, we seek to integrate this dynamic account of interpersonal coordination and collaboration with the substantial body of literature on the social consequences of memory and collaborative recall.

Here, we take preliminary steps in this direction by examining collaboration on a relatively unconstrained memory task utilizing trivia-type clues. The trivia clues allow us to conceptualize the dynamics of remembering as a search process across pre-existing memory space, as participants consider many possible solutions before narrowing down on an objectively correct answer. Extending the work of Szary and Dale (2013), the current study presents four rounds of trivia clues to dyads who work either independently or collaboratively on each round to find solutions. After the game, a more traditional recall test measures recall for the solutions achieved during the trivia game.

Results from Szary and Dale (2013) showed that, on average, dyads performed better (answered more clues correctly, answered them faster, answered them more accurately, and were more likely to remember them later in a surprise recall task) during collaborative rounds as compared to individual rounds. However, these results did not address the performance of nominal groups, nor the effects of familiarity on group performance. The current study uses the trivia paradigm with the primary modification that familiar and non-familiar dyads were recruited, and results are presented in terms of the more stringent nominal comparisons. In order to increase the quantity and quality of interactions, the trivia game was extended to include more clues and provide more time for each clue. Although our familiarity measure was extremely limited, we present our encouraging findings that (1) collaborative inhibition can be eliminated by even a short period of familiarity; and (2) collaborative facilitation is stronger for dyads with more familiarity.

Methods

Participants

Participants were recruited from a subject pool of University of California, Merced undergraduate students who participated for course credit. For the non-familiar condition, two independent timeslots were posted on the SONA research participation system. For the familiar condition, one timeslot was posted and each participant was asked to bring a friend. After the task, participants were surveyed to determine the extent and nature of their relationship, if any, in order to categorize them into the appropriate conditions. In total, we collected data from 68 participants (46 female; 22 male), with a mean age of 19.9 *(SD = 2.8)*. Both the familiar and non-familiar conditions included 17 dyads (34 participants; 20 females, 14 males in non-familiar; 26 females, 8 males in familiar). Given our lenient recruitment procedure, the length of relationships in our familiar condition ranged from 2 months to 3 years ($M = 15.59$ months, $SD = 10.52$).

Procedure

Upon arrival, all dyads were given 5 minutes for introducing and familiarizing themselves with one another[1]. Partners were seated across from each other at a table with two HP Chromebook laptops between them, on which the stimuli were presented. The partners could see only their own workspaces, but were able to observe one another over the tops of their screens. Each dyad participated in multiple rounds of a trivia game, working either individually or collaboratively on each round. After all rounds of the trivia task were finished, the experimenter instructed each participant to open a blank text file and, working independently, spend 5 minutes recalling and listing as many of the trivia game answers as possible. Finally, a brief post-experimental survey was performed and participants were dismissed.

Materials

Trivia Game The stimuli consisted of 60 trivia clues of medium-level difficulty (answered correctly about half of the time) as described in Szary and Dale (2013). The clues represent a variety of types of question: cultural knowledge ("Kill Bill" star Thurman: *UMA*); general knowledge (U.S. spy organization: *CIA*); word definitions (Gift to charity: *DONATION*); logic (Hour subunits: *MINUTES*); fill-in-the blank ("If all ____ fails": *ELSE*); categories (Tulips and irises, for example: *FLOWERS*); and sayings ("Rolling in dough" meaning: *RICH*). Examples show the answers in italics.

Clues were presented using a trivia computer game developed by the authors using Adobe Flash CS5. Clues are sorted into 4 rounds of 15 clues each, and participants are instructed to complete each round either collaboratively (C), or independently (I). During the collaborative rounds, partners are encouraged to discuss clues and work together to solve them as a team. Across dyads, the order of the clues and condition (which could be either I-C-I-C or C-I-C-I) was randomized and counterbalanced. Clues were presented one-at-a-time, along with blank squares corresponding to each letter of the correct answer. After an answer is typed in, the space-bar is used to submit the answer. If correct, a checkmark icon appears briefly and the program moves on to the next clue, as shown in Figure 1. If incorrect, a red "X" marks each incorrect letter, which can then be corrected. Participants may try as many times as necessary to submit a correct answer, but if they don't succeed within 30 seconds, the program displays a "Time's Up!" icon and moves on to the next clue.

Between each round, participants are given their new conditions and asked to wait for their partners (if necessary) so they can move on together. Partners indicated their progress to each other ("Working", or "'Ready when you are!") using

[1] In our (unpublished) experience, this familiarization period was crucial for non-familiar dyads to become comfortable interacting with one another during the task. This procedure was replicated for familiar dyads for the purpose of consistency.

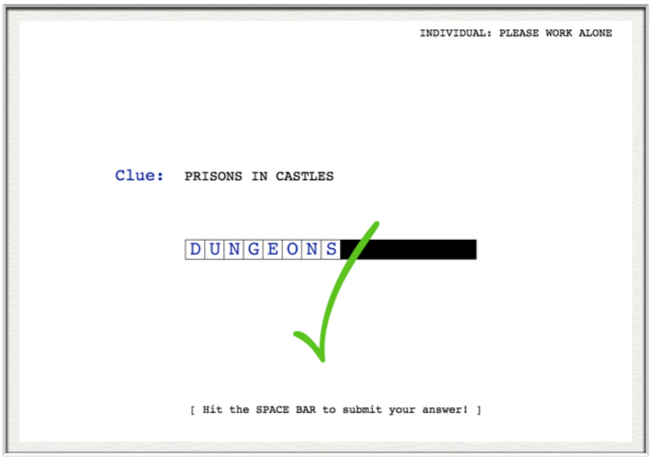

Figure 1: Screenshot from the trivia game, showing a successfully answered clue.

flip cards placed on the table beside their computers. For each clue the program recorded whether a correct answer was submitted before time ran out and, if so, the elapsed time before the answer was submitted, as well as the number of incorrect attempts preceeding each correct answer.

Post-experimental Survey After the trivia game and recall task, participants were asked to privately rate their team's effectiveness when working together. Ratings were performed on a 1-7 scale where 1 represented "not at all effective" and 7 represented "perfectly effective". Participants were also surveyed to determine whether they knew each other before the experiment or not and, if so, the length of their relationship.

Data Analysis

The current study used a 2 (familiar or non-familiar; a between-dyad manipulation) x 2 (collaborative or individual solving; a within-dyad manipulation) mixed design. Our dependent variables included (1) the number of correct answers achieved; (2) speed, measured as the amount of time in milliseconds that elapsed before each correct answer was submitted; (3) the number of errors (incorrect submission attempts) that preceded each correctly submitted answer; and (4) the number of correct answers recalled (that is, during the subsequent recall task).

Nominal Aggregation Because both participants used their own computer workstations to submit answers, we have two unique datasets for each dyad. Here, we combine individual members' performances into one group-level dataset (per dyad). That is, for each dyad $D_{i=[1,\dots,n]}$ (where n is the number of dyads) we compute the dataset D_i as the combination of both its participants' datasets (P_i^1 and P_i^2). Consistent with the literature on collaborative recall, we combine unique datasets into one using an extension of nominal aggregation to compute nominal performance (which is the hypothetical, optimal combination of P_i^1 and P_i^2). To illustrate how we calculated nominal aggregate performance in our task, consider stepping through each clue $j = [1,\dots,60]$ for each D_i. The performance measures {correct (yes/no); time (ms); errors (#); recall (yes/no)} for our nominal D_{ij} are calculated as follows:

(Case 1): If both P_{ij}^1 and P_{ij}^2 are correct, D_{ij} is also correct. Time is computed as the smaller (faster) of P_{ij}^1 and P_{ij}^2, and errors are computed as the smaller (most accurate) of P_{ij}^1 and P_{ij}^2. If either P_{ij}^1 or P_{ij}^2 is correctly recalled, so is D_{ij}.

(Case 2): If only one of P_{ij}^1 and P_{ij}^2 is correct, D_{ij} is correct and time, errors, and recall are set equal to those of whichever P_{ij} was correct.

(Case 3): If neither P_{ij}^1 nor P_{ij}^2 is correct, D_{ij} performance is {no; null; null; no}.

For internal consistency, the same nominal aggregation procedure was used for both collaborative and independent rounds (because even during collaboration participants had their own computers, resulting in two datasets for *all* rounds). However, aggregation is expected to play a negligible roll for the collaborative datasets, as dyads talked and submitted answers together resulting in largely similar datasets. For the sake of consistency with the literature, we refer to aggregated collaborating groups as simply "collaborative groups", while we refer to the aggregated (hypothetical) groups computed from independent rounds as "nominal groups". We then compute a difference measure as collaborative minus nominal group performance (or the reverse, for our reverse measures of speed and accuracy). Thus, performance difference > 0 always indicates collaborative facilitation, while performance difference < 0 indicates collaborative inhibition.

Discrepancy Lastly, we compute a discrepancy measure for each dyad that indicates how similar or dissimilar its members are to each other. This measure is computed as the magnitude of the difference between each dyad member's average performance during the (two) individual rounds.

Results

Performance

Across conditions, nominal groups performed significantly better than collaborative groups on two performance measures (number correct and speed), indicative of collaborative inhibition (details for all performance measures are given in Table 1). However, nominal groups performed significantly worse on the other two measures (minimization of errors and number recalled), indicative of collaborative facilitation. Non-familiar dyads displayed a similar pattern of results, showing significant indications of collaborative inhibition in terms of number correct and speed, but only showed collaborative facilitation in terms of minimization of errors (and not number recalled). Conversely, familiarity was found to ameliorate the negative consequences of collaboration. Within familiar dyads, nominal and collaborative groups were not significantly different from one another in terms of number correct or speed, but collaborative groups were (still) significantly better at minimizing errors and at subsequent recall, indicating collaborative facilitation. Unpaired t-tests between performance metrics for familiar and non-familiar dyads did not reach significance. The discrepancy measure for each dyad was weakly, negatively correlated with the dyad's collaborative performance, but this also failed to reach significance. Still, when the individuals composing a dyad performed more similarly during individual rounds, their collaboration tended to be more successful (Figure 2).

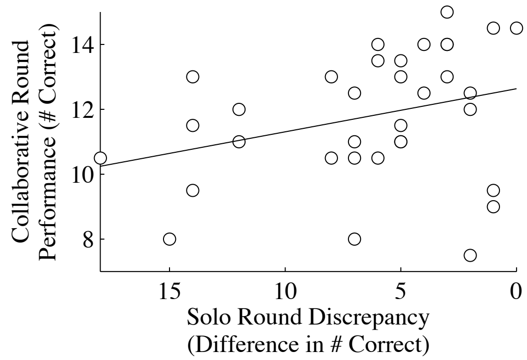

Figure 2: Collaborative performance plotted against discrepancy during the individual rounds, for each dyad. Regression line ($m = -0.13$).

Table 1: Means and standard deviations (in parentheses) for each performance measure. Columns show nominal and collaborative conditions, as well as performance difference (where instances of collaborative facilitation are bold). Rows show overall ($n = 34$), familiar ($n = 17$), and non-famliar ($n = 17$) results, respectively, for each measure.

	Nominal	Collaborative	Diff.
# Correct	12.53 (1.77)	11.79 (2.00)	−0.74**
Fam.	12.38 (1.68)	12.09 (2.03)	−0.29
Non-fam.	12.68 (1.90)	11.50 (2.00)	−1.18**
Speed (ms)	6861 (1997)	7895 (1745)	−1034**
Fam.	6740 (2099)	7648 (2064)	−908
Non-fam.	6983 (1946)	8141 (1428)	−1158*
# Errors	0.25 (0.20)	0.11 (0.09)	**0.14*****
Fam.	0.21 (0.19)	0.10 (0.08)	**0.11***
Non-fam.	0.28 (0.20)	0.12 (0.11)	**0.16****
# Recalled	4.26 (1.28)	5.12 (1.74)	**0.86***
Fam.	4.29 (1.16)	5.38 (1.92)	**1.09***
Non-fam.	4.24 (1.43)	4.85 (1.54)	**0.61**

Note. Asterisks indicate a significant difference between a given row's nominal and collaborative means, using paired t-tests, where $*p < 0.05$, $**p < 0.005$, $***p < 0.0005$.

Recall By Round We replicated previous findings (Szary & Dale, 2013) that dyads remember more from rounds on which they collaborated, and in general recall more from the later (more recent) rounds. This first result is presented in Table 1, which shows that the number of items recalled was higher during collaborative rounds across all dyads, as well as for familiar dyads, but not for non-familiar dyads. When comparing items recalled from each of the four rounds separately, it is apparent that this difference manifests largely in the superior fourth round performance of familiar collaborator groups. Table 2 shows the average number of items recalled from each round. There are no significant differences between any of the comparisons (familiar–non-familiar; nominal–collaborative; or any of the other 2x2 comparisons) in any round except round 4, where familiar collaborator groups recall significantly more than familiar nominal groups (unpaired $t(15) = 2.26, p < 0.05$). Figure 3 plots the data from Table 2 to further illustrate this effect.

Qualitative Measures of Familiarity

Length of Relationship A preliminary analysis of the effect of relationship lengths on performance was computed for the number of correct answers achieved. Figure 4 shows the performance difference for number of answers achieved (from Table 1) as a function of each dyad's relationship length. Across all dyads, the difference measure is positively correlated with length of relationship, $r(32) = 0.42, p < 0.05$. That is, collaborative facilitation is greater for dyads who knew each other longer. This trend remains but is no longer significant when considering only familiar dyads. The existence of a subtle but noteworthy length-of-relationship effect can be further demonstrated by grouping dyads by the length of their relationships.

As shown in Table 1, dyads with no relationship ($rel_{length} = 0$) exhibited a performance difference of -1.18 ($SD = 1.24$), indicative of significant collaborative inhibition. Familiar dyads exhibited a performance difference of -0.29 ($SD = 1.29$), indicative of weaker collaborative inhibition. Among the 9 familiar dyads with self-reported relationship lengths of 12 months or less ($rel_{length} \leq 12$; $M = 7.67$ months, $SD = 4.30$), a performance difference of -0.89 ($SD = 1.47$), indicating even weaker collaborative inhibition, was observed. For the 8 dyads with longer relationships ($rel_{length} > 12$), $M = 24.5$ months, $SD = 7.76$), there was a performance difference of 0.34 ($SD = 0.57$), indicating collaborative facilitation. Overall, more familiar dyads were more likely to experience facilitatory effects of collaboration. This distinction was reliable for $rel_{length} > 12$ as compared to: (1) $rel_{length} \leq 12$ (unpaired $t(15) = 2.27,\ p < 0.05$); (2) $rel_{length} = 0$ (unpaired $t(23) = 3.35,\ p < 0.005$); and (3) both $rel_{length} \leq 12$ and $rel_{length} = 0$ together (unpaired $t(32) = 3.04,\ p < 0.005$).

Subjective Ratings of Collaborative Effectiveness Subjective reports of effectiveness during collaboration were col-

Table 2: Mean recall and standard deviations (in parentheses).

	Nominal	Collaborative	Overall
Round 1	3.56 (1.36)	4.22 (2.07)	3.91 (1.78)
Fam.	4 (1.51)	4 (2.06)	4 (1.77)
Non-fam.	3.13 (1.13)	4.44 (2.19)	3.82 (1.85)
Round 2	3.56 (1.36)	4.375 (2.06)	3.94 (2.42)
Fam.	4 (1.73)	4.75 (1.73)	4.35 (2.26)
Non-fam.	3.11 (2.37)	4 (2.07)	3.53 (2.21)
Round 3	4.81 (2.14)	5.11 (2.37)	4.97 (2.24)
Fam.	4.5 (2.20)	5.89 (2.42)	5.24 (2.36)
Non-fam.	5.13 (2.17)	4.33 (2.18)	4.71 (2.14)
Round 4	5.11 (2.49)	6.88 (1.86)	5.94 (2..36)
Fam.	4.67 (2.12)	7 (2.12)	5.76 (2.39)
Non-fam.	5.56 (2.88)	6.75 (1.67)	6.11 (2.39)

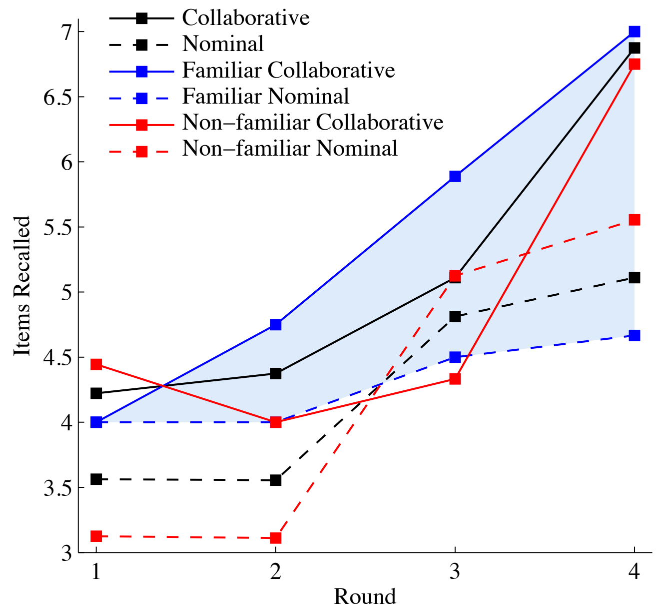

Figure 3: Recall by round for each group. Solid lines represent collaborative groups, dotted lines denote nominal groups. Black lines are means across all dyads, while blue and red lines are means for familiar and non-familiar dyads, respectively. The shaded area highlights the difference between familiar collaborative and familiar individual groups for illustrative purposes.

lected individually for each participant. The mean of collaborative effectiveness ratings was 5.91 ($SD = 0.84$). Dyad level aggregates were computed as the sums of their component members' ratings, in order to look for a relationship between reported effectiveness and actual task performance. None was found: self-reports of effectiveness did not differ as a function of actual effectiveness (as measured by performance metrics), nor as a function of task condition.

General Discussion

The current paper builds upon the methods and results of Szary and Dale (2013) by considering the role of familiarity and reporting nominal group performance. While collaborative inhibition is observed, which is consistent with much of the collaborative recall literature, it is observed only for certain performance measures and for certain dyads. That is, across all dyads a significant collaborative inhibition is observed in terms of the number of trivia clues correctly answered, and the speed of achieving those answers. This significant inhibition remains for non-familiar dyads, but no difference is observed between collaborative and nominal groups who are familiar to one another. Familiarity, in this case, has protected against the negative consequences so often observed in the social remembering literature. In fact, we demonstrate here a number of instances in which collaborative *facilitation* can actually be observed for a memory task. For example, dyads made less errors during collaborative rounds, and recalled more from the rounds on which they collaborated. This effect is even stronger for the subgroup of familiar dyads.

Despite the poverty of our familiarity measure, we uncovered a correlation between relationship length and collaborative facilitation. On most measures we were able to confirm that familiar dyads worked better together (consistent with Wegner et al., 1991; Harris et al., 2010, as discussed earlier). Additionally, we found that similarity between two participants was associated with their success as a dyad. This is consistent with existing work on joint decision-making, which shows that collaboration on low-level perception tasks is more successful when dyads are composed of members with similar perceptual abilities, and when those members use similar task-relevant linguistic forms (Fusaroli et al., 2012).

More than any single conclusion, this collection of results suggests that collaborative remembering is a complex task, the success of which is modulated by many interacting factors (familiarity, similarity) and changing components (different knowledge landscapes for each clue, different external contexts across rounds). It is perhaps most appropriately approached from the dynamic, joint-action perspective of a coordinative structure, as described earlier. Ongoing work seeks to investigate these data from this perspective, which will involve utilizing complex dynamics methods to uncover the mechanisms involved with what often feels, informally, like a qualitative shift from the paradigm of successful collaboration (which captures, for example, the concepts of TM and instances of collaborative facilitation) to the paradigm of unsuccessful collaboration (captured by collaborative inhibition and retrieval disruption, for example). See Richardson, Dale, and Marsh (2014) for a treatment of these methodologies and their theoretical implications.

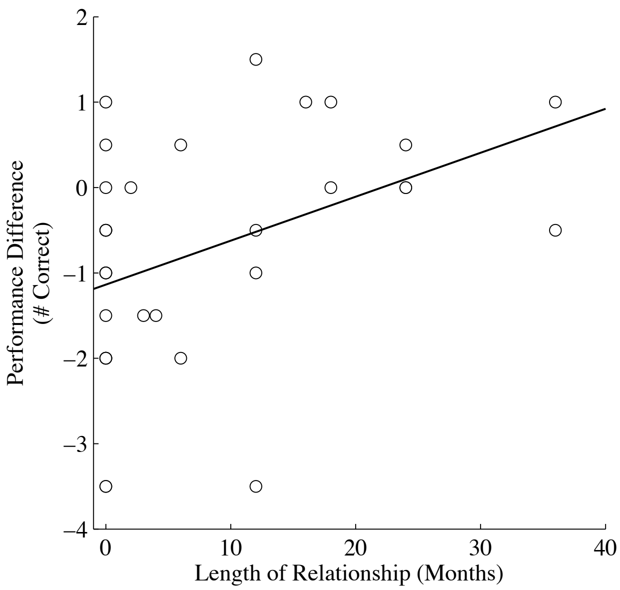

Figure 4: Performance difference as a function of relationship, in months. Regression line $m = 0.051$.

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