ABSTRACT

THE EFFECTS OF GROUP COMPOSITION AND TASK STRUCTURE ON TACIT COORDINATION IN SMALL GROUPS

by Edwin R. Shriver

This experiment explores tacit coordination processes in three-person groups for a word recall task consisting of three subtasks that vary in difficulty. The task consisted of 10 iterations with feedback after each trial. Groups were required to coordinate either by attempting to recall the same words or different words across the members. Prior to completing this task, the group members were each given feedback suggesting that they had either performed similarly or differently on a performance assessment related to word recall. Partial support was obtained for the hypothesis that coordination efficiency would be greater when there was congruence between the participants’ perceptions of their other group members and the coordination requirement of the task than when these factors were incongruent with one another. The hypothesis that coordination efficiency would improve over time was also supported. The limitations of the findings as well as possible directions for future research are discussed.
THE EFFECTS OF GROUP COMPOSITION AND TASK STRUCTURE ON TACIT COORDINATION IN SMALL GROUPS

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When an organization forms a committee or task force, a group is being called upon to pool the talents and efforts of its members into a collective product. For example, a group of bank executives may be assigned to design a new kind of bank account, or a software development team may be asked to design a new program for a client. According to Steiner’s (1972) taxonomy of group tasks, both examples are divisible tasks. Such tasks “make a division of labor feasible” because they can be divided into separate subtasks that can be assigned to individual group members and/or smaller committees within the group (Steiner, 1972, p. 16). This division of labor is part of the process of group coordination, wherein group members decide how to allocate and pool their individual efforts in order to perform a task. In tasks that involve a division of labor among group members, the success of group coordination is an important determinant of a group’s productivity (Wittenbaum, Vaughan, & Stasser, 1998).

In Steiner’s (1972) view, a group’s actual productivity is a function of its potential productivity minus process losses. Potential productivity sets the upper limit on the level of efficiency that a group can achieve, and this is conceptualized as the total amount of external resources that are available to a group to complete its task. Actual productivity, on the other hand, is the level of task efficiency that a group ends up achieving in reality. A group’s actual productivity almost never reaches its potential productivity because of process losses that are incurred during the group interaction. Process losses can result from both social loafing and coordination inefficiencies (Steiner, 1972; see also Hackman & Morris, 1975).

**Integrative Model of Group Coordination**

According to Wittenbaum, Vaughan, and Stasser (1998), group coordination can be classified according to two factors: time and explicitness. For the time factor, coordination can develop both prior to a group beginning a task and while a group is in the process of working on a task. Coordination also varies in its level of explicitness. Explicit coordination is the product of verbal communication and/or written procedures that are shared among the group members. Tacit coordination, on the other hand, results from the nonverbal expectations of group members (Wittenbaum, Stasser, & Merry, 1996; Wittenbaum et al., 1998). Based on these two factors, Wittenbaum et al. (1998) describe four modes of coordination: tacit pre-coordination (also referred to as anticipatory tacit coordination; Wittenbaum et al., 1996), in-process tacit coordination, explicit pre-coordination, and in-process explicit planning. Anticipatory and in-process tacit coordination are the coordination modes that are most relevant to the proposed study. Although these modes differ in terms of the time in the group’s life in which they occur, the same basic processes underlie both types of tacit coordination.

**Tacit Coordination**

Wittenbaum et al. (1996) define tacit coordination “as the synchronization of members’ actions based on unspoken assumptions about what others in the group are likely to do” (p. 129). Although explicit coordination can certainly play a role in team performance, evidence from the literature suggests that in many group situations, tacit coordination is also commonplace (Wittenbaum et al., 1998). For example, Gersick (1988) observed that naturally-occurring groups developed persistent patterns of interaction in “as early as the first few seconds of a group’s life” (p. 33). Gersick (1988) also suggested that the “sheer speed” with which these consistent patterns of interaction were established led her to believe that they were in place before the groups’ first
meetings (p. 33). Moreover, Bettenhausen and Murnighan (1985) reported similar findings. They observed that norms emerged early in group life and that these norms were based on scripts (i.e., the group members’ prior expectations about the task and each other; see also Hackman and Morris, 1975). Both of these accounts are consistent with the idea that groups engaged in anticipatory tacit coordination processes (cf. Wittenbaum et al., 1996).

According to Gersick (1988), the groups’ early coordination patterns were based on the “members’ expectations about the task, each other, and the context” (p. 33). In this way, Gersick’s (1988) findings also support Wittenbaum et al.’s (1996) model of anticipatory tacit coordination. According to Wittenbaum et al. (1996), anticipatory tacit coordination is the result of 1.) member expectations, 2.) task assessment, and 3.) resource allocation. Group members develop member expectations based on what they expect others to do as well as how successful they anticipate these others will be at the task (see also Hackman and Morris, 1975). Task assessment refers to the group members’ assessment of what the group has been asked to do and what is required for the group to be successful. Based on their member expectations and task assessment, group members then tacitly decide how to allocate their resources in a way that will maximize group outcomes.

Hackman and Morris (1975) found that groups engaged in little explicit discussion of strategy over time. They suggested that groups tend to be task focused and thus do not take the time to discuss and develop a strategic plan for completing the task. Fixation with working on the task itself to the exclusion of planning can result in poor performance because groups get stuck in the patterns established in their early interactions (Hackman & Morris, 1975). In addition, Gersick (1988) observed that, rather than discussing strategy explicitly as time went on, “frameworks were established implicitly, by what was said and done repeatedly in the group” (p. 17). This suggests that as time goes on, some groups may continue to rely largely on tacit coordination. Specifically, while in the process of working on the tasks, Gersick’s (1988) groups appeared to rely on what Wittenbaum et al. (1998) refer to as in-process tacit coordination.

Transactive memory. The development of transactive memory systems also can be conceptualized in terms of tacit coordination processes (Wittenbaum et al., 1998). Wegner (1987) defines a transactive memory system as “a set of individual memory systems in combination with the communication that takes place between individuals” (p. 186). This is a tacit process because although group members communicate information within their area of expertise to the rest of the group, they are not explicitly assigned responsibility for remembering this information (see Wittenbaum et al., 1998). As group members learn about each other’s areas of expertise, they can develop implicit expectations about the types of information that others in the group are likely to attend to and remember. This process corresponds to the member expectations component of Wittenbaum et al.’s (1996) model of anticipatory tacit coordination. Based on the expectations that the group members develop about one another, they then can focus their attention on information that others are unlikely to remember and away from information that is within the other group members’ areas of expertise. In this way, although no one individual can remember all of the available information, each individual still has access to the information that they cannot remember through their other group members. This is similar to the resource allocation component in Wittenbaum et al.’s (1996) model.

In sum, the literature suggests that both anticipatory and in-process tacit coordination are prevalent phenomena in groups. In addition, the contemporary research implies that both forms of tacit coordination have important implications for group performance. However, although several of the findings in the literature can be interpreted in terms of tacit coordination, little
research has been done with the goal of assessing tacit coordination directly (see Birchmeier, 2004; Wittenbaum, et al., 1996, for exceptions). Given that groups make widespread use of their unspoken assumptions about both the task and each other, it is important to understand more about the implications that tacit coordination processes have for group productivity and team performance.

Advantages of Tacit Coordination

According to Camerer (2003), tacit coordination is an under-researched topic because many researchers do not see the practical significance of the concept. Researchers may find that it is more rewarding to study the means by which groups can be encouraged to explicitly communicate more effectively. Contrary to intuition, however, explicit coordination does not always result in maximum group efficiency (Wittenbaum et al., 1998). Although effective tacit coordination strategies take time to develop, once established, they can result in greater group efficiency than can be attained with explicit coordination strategies (Wittenbaum et al., 1996; Wittenbaum et al., 1998; Wegner, 1987; Wegner, Erber, & Raymond, 1991). Efficiency improves because groups can spend their time working on the task itself rather than discussing strategy. This advantage is particularly pronounced for groups that are familiar with their tasks and for whom rapid task completion is important (Wittenbaum et al., 1998).

In addition, research has shown that existing tacit coordination systems can lead to interference when group members are explicitly assigned to their roles within the group. For example, although newly-formed couples benefited from explicit role assignments, Wegner et al. (1991) found that role assignments interfered with transactive memory and thus reduced the combined memory performance of natural couples. Similarly, Van Huyck, Gillette, and Battalio (1992; cited in Camerer, 2003) reported that most participants followed the experimenter-assigned strategy when it did not interfere with a different focal point (in this case, a tacit coordination rule). However, when the experimenter-assigned strategy conflicted with tacit coordination, the participants followed the experimenter-assigned strategy only about 50% of the time. This suggests that imposing an explicit coordination strategy can reduce performance in a group that has a pre-existing tacit coordination system.

Tacit coordination also can be more effective than explicit coordination when explicit discussion of a strategy is likely to generate intragroup conflict (Wittenbaum et al., 1998). For example, tacit coordination may be particularly important when group members are assigned to subtasks based on past performance or stereotypes (Wittenbaum et al., 1998). When a group task is made up of subtasks that vary in degree of difficulty, group performance will be maximized when the abilities of the members are directly related to the difficulty of the subtasks. Wittenbaum et al. (1998) suggested that groups may be uncomfortable explicitly discussing their relative ability as information and that such a discussion could lead to intragroup conflict that would then lead to a decline in group performance. Although no research has been done to specifically address this question, this suggests that tacit coordination will be particularly important for performance when the group’s success depends on coordinating so that group members complete the subtasks that are appropriate to their skill level.
Proposed Research and Hypotheses

The proposed study will look at whether group members use relative ability information as a cue for tacit coordination. Participants will be given false feedback about their performance on an individual task before they complete a separate group task. The feedback from the individual task will be manipulated in order to compose groups that are either homogeneous or heterogeneous in terms of the ability levels of their members.

In order to understand how tacit coordination is affected by the task structure, the coordination requirement for the group task will be manipulated. In the matching condition, the group’s goal will be for its members to match their responses with one another, whereas, in the mismatching condition, the group’s goal will be for its members to avoid overlap in their responses. This manipulation is designed to conform to the distinction Steiner (1972) made between conjunctive and disjunctive group tasks. In conjunctive tasks, group productivity is maximized when all of the group members focus their effort on the same subtask. Because all of the group members need to be able to successfully carry out the same subtask, group productivity in a conjunctive task is limited by the abilities of the least competent member of the group. The matching condition represents a conjunctive task. Group productivity in disjunctive tasks, in contrast, depends on the group’s ability to develop and maintain an effective division of labor. The goal in a disjunctive task is for the group members to independently focus on different subtasks. In this case, there is no incentive for more than one group member to successfully complete the same subtask. The mismatching condition represents a disjunctive task.

Congruence between the coordination requirement and the group’s composition may be critical for a successful tacit coordination strategy to develop. In the case of a heterogeneous group, the group members are given information that each of them is the most competent, the least competent, or somewhere in between respectively. Therefore, in the case of a group task consisting of three subtasks that vary in their degree of difficulty, the rational strategy is to assign each group member to the subtask that corresponds to their level of perceived ability within the group. This is because group performance will be optimized when the most competent group member is assigned the most difficult subtask, the group member in between the other two is assigned the moderately difficult subtask, and the least competent group member is assigned the least difficult subtask. Thus, if the group’s goal is to coordinate by mismatching and avoid a duplication of effort, then the information provided to the heterogeneous groups should suggest a rational strategy for coordinating. In contrast, when the group is homogeneous, the only thing that the group members know is that they are all similar to one another. When the group is trying to decide how to assign the group members to different subtasks that vary in difficulty, the information provided to the homogeneous groups does not suggest a rational basis for making these assignments. Thus, there will be a lot of ambiguity about who should do what, and this will make it more difficult for each of the group members to anticipate what the others are likely to do. Because of this, when the goal is to mismatch, heterogeneous groups should be more successful at developing a tacit coordination strategy than homogeneous groups.

However, the advantages afforded to the heterogeneous groups are contingent on the type of task. When the group’s goal is for everyone to match by focusing on the same subtask, the information provided to the heterogeneous groups may be confusing in the sense that it does not suggest a strategy for choosing which subtask that everyone should focus on. In this case, because this is a conjunctive task, group performance will be maximized when the group chooses to focus on the most difficult subtask that everyone in the group is capable of successfully
completing. For heterogeneous groups, there are conflicting strategies that may interfere with successful coordination. On the one hand, it would be rational to focus on the least difficult subtask in order to try to accommodate the least competent group member (Birchmeier, 2004); however, on the other hand, it is also the case that the more difficult subtasks have higher potential payoffs for the group. Thus, the information available to heterogeneous groups does not suggest a single rational strategy for coordinating by matching. In contrast, homogeneous groups may be more successful than heterogeneous groups at coordinating by matching because they perceive themselves as having similar ability levels. Therefore, once the group learns to focus on a subtask that all of the group members can complete successfully, homogeneous groups should be less motivated to try to switch because the difficulty of the task is perceived as appropriate to the ability levels of all of the group members. In heterogeneous groups, however, group members may be more motivated to switch in order to try to make adjustments that accommodate the differing ability levels within the group. Thus, if the group has an experience where it succeeds or fails on a subtask, some of the group members may reflexively adjust either up to a more difficult subtask in the former case or down to a less difficult subtask in the latter case in order to try to accommodate the differing ability levels of the group members. Because of this, heterogeneous groups may have a more difficult time developing a successful tacit coordination strategy for matching than homogeneous groups.

Three hypotheses are proposed. The first two hypotheses describe the nature of the predicted interaction between group composition and the coordination requirement. In the matching condition, homogeneous groups are expected to coordinate more efficiently than heterogeneous groups, whereas, in the mismatching condition, the opposite finding is predicted such that heterogeneous groups are expected to coordinate more efficiently than homogeneous groups. The third hypothesis predicts that coordination efficiency will improve for all groups over time as the group members gain experience working with each other on the task.

Method

Participants

Data were collected from 204 participants (106 males, 94 females) who were composed into a total of 68 three-person groups. Data were not collected from 33 participants in 11 groups because they were unable to complete the experiment due to networking problems. Of those who participated and were able to complete the experiment, 120 were recruited from the Miami University subject pool, 78 were paid $10 for their participation, and 6 were volunteers. Paid participants were recruited around campus by posting flyers in the psychology department, contacting student organizations, and sending notices out through both the honors college and graduate student association listservs. All participants were undergraduates with the exception of a few graduate students. Graduate students from the psychology department were excluded due to concerns that they may already be aware of some of the experimental hypotheses. Due to a clerical error, some of the participants took part in the experiment more than once. Because of this, the data from an additional 33 participants in 11 groups had to be dropped from the analyses. Thus, all of the analyses were conducted on data collected from 171 participants in 57 groups.

1 A computer error resulted in gender data not being recorded for four of the participants.
In addition to receiving partial course credit or payment for participation, the participants also had the opportunity to win monetary prizes that were awarded on the basis of their group’s performance. Within each of the experimental conditions, participants in the best-performing groups received $25 per person, and participants in the runner-up groups received $10 per person.

Stimulus Materials

The stimulus materials were presented via computers using a program developed with Microsoft® Visual Basic 6.0™. The experiment consisted of two individual tasks and a group task.

Individual verbal task. The individual verbal task consisted of a series of 30 sample Miller Analogies Test (MAT) items. For each item, participants were asked to select the best answer from four possible response options. Participants were required to answer the items in the order presented and, once they moved on from an item, they could not return to any of the previous items. They were given 3 min to respond to as many of the items as possible.

Individual math task. The individual math task consisted of a series of 23 arithmetic problems that participants were asked to solve without the assistance of aides such as pencil-and-paper or calculators. The problems were presented individually on the computer screen along with four possible responses. For each problem, participants were asked to select the answer that was either correct or nearest to correct from among the response options. The procedures for this task were similar to those for the verbal task. Participants were given 3 min to solve as many of the problems as possible. They had to solve the problems in order, and, once they moved beyond a problem, they could not return to any of the previous problems.

Group word recall task. The word recall task was a group task that was designed for the participants to complete in coordination with the other members of their three-person groups. For each trial, three word lists were presented that varied in length (10 words, 15 words, and 20 words respectively). Thus, the group task consisted of three subtasks that varied in their degree of difficulty (i.e., presumably a longer list of words is harder to memorize than a shorter list). The lengths of the lists were chosen on the basis of the results of pretesting. The number of words on the easy list was intended be somewhat below the number of words that the average person could memorize in the allotted time, and the number of words on the most difficult list was intended to be somewhat above the number of words that the average person could memorize in the allotted time. The number of words on the moderately difficult lists fell between these two extremes. Each of the lists was intended to be short enough that an average person could memorize most of the words on any one of the lists, but long enough that it would be difficult for a single individual to successfully memorize most of the words on two or more of the lists. In this way, the task was made difficult enough that the participants were required to work together in coordination with their other group members in order to be successful.²

Although it was possible for the participants to switch between and study any of the three lists, they only were able to select and view one list at any given time. The words on each of the lists were held constant across all of the group members; however, both the order of the presentation of option buttons for displaying the lists and the order of the words within each of

² Results obtained in the final study suggested that the list lengths that were chosen approximated these criteria. Participants individually recalled a mean of 10.24 words per trial (SD = 2.80) for trials 1 through 5 of the word recall task and a mean of 10.53 words per trial (SD = 3.22) for trials 6 through 10.
In the memorization phase, the participants were given 1.5 min to view and study the words on the three word lists. Initially, none of the lists were visible until the participant selected one of the option buttons corresponding to one of the three lists. In the recall phase, the participants were given 1 min to type as many words as they could recall into a textbox. Although the responses were not case sensitive, correct spelling was required for a word to be counted as correctly recalled. The importance of spelling was strongly emphasized in the instructions. There was no penalty for reporting incorrect words.

Construction of the word lists. The words to create the word lists were selected based on norms compiled by Toglia and Battig (1978). Toglia and Battig (1978) used cluster analysis to group words on the basis of similarity along the dimensions of concreteness, imagery, categorizability, meaningfulness, familiarity, number of attributes, and pleasantness. Ratings of words along these dimensions were based on research conducted with American college students. Words matched along these attributes should also be similar in their ease of recall. Thus, the difficulty of the word lists will be a function of the number of words that appear on a list and not of the specific words that are on a list. Words for the lists were drawn from Cluster 7 (see Toglia & Battig, 1978). Cluster 7 was selected primarily because it is the largest of the eight clusters reported in Toglia and Battig (1978). Words in this cluster tend to be high in concreteness, imagery, and categorizability and are also above average in meaningfulness and familiarity. They are slightly below average in pleasantness and number of attributes (Toglia and Battig, 1978). A computer program was used to randomly generate the word lists from the Cluster 7 words (565 words total). Because the procedure used sampling without replacement, no word appeared more than once on any of the lists during any of the trials of the word recall task.

Procedure

Participants were assigned to three-person groups to complete the study. When the participants arrived for the study, an experimenter escorted each participant to a separate cubicle with a computer workstation. All the participants were instructed to remain quiet until after the completion of the experiment. The group members were not permitted to communicate with one another during any part of the experiment. Initially, the computer displayed a welcome screen. This screen instructed the participants to wait until the experimenter told them to begin and told them that further instructions would follow and would be displayed on their computer screens. Once everyone was seated at their workstations, the experimenter told the participants that they may begin the experiment and to click the start button in the lower-right corner of their screens. Next, the instructions for either the math task or the verbal task were displayed for 2 min. The order in which the individual tasks were completed was counterbalanced across conditions. Throughout the experiment, a timer at the bottom of the computer screen enabled the participants to keep track of the amount of time remaining at each stage. After reviewing the instructions, the participants then completed the corresponding task. They then viewed the instructions for the other individual task for 2 min and completed that task as well. After completing both individual tasks, they were provided with false feedback about both their own and their other group members’ performance. The group composition manipulation was embedded within this feedback.
False feedback was provided for the performance of every group member on each of the two individual tasks. This feedback was presented in the same order that the tasks had been completed. That is, either the math feedback appeared on top and the verbal feedback below or vice versa. Both types of feedback were presented as percentiles and were displayed along two separate number lines ranging from 0 to 100. This was done to increase the salience of the degree to which the group members were similar or different in terms of their relative performance. The participants were told that the percentile ratings were based on norms that had been established with a nationally representative sample of American college students. Percentiles were used in place of raw scores because it was feared that the participants might realize the feedback was false if raw scores were used. This is because many of the participants would likely have a rough number in mind for the number of items on each task that they believed they answered correctly. If the feedback differed notably from this expectation, then some of the participants might question the validity and/or truthfulness of the feedback. By using percentiles, it was harder for the participants to make accurate judgments about their own performance. In addition, both tasks were speeded and consisted of more items than most people could accurately respond to in the allotted time. Thus, even if someone believed that they responded to every item that they answered correctly, it would be possible that someone else could have answered more of the items correctly, and thus could have a higher percentile ranking than them. Furthermore, the items themselves were designed to be ambiguous. In the case of the Miller analogies test items used for the verbal task, these items are ambiguous in the sense that often one or more of the answers could logically work even though there is a single best correct answer. This ambiguity makes it difficult to arrive at a conclusive judgment of whether one has answered an item correctly or incorrectly, and thus makes it more difficult to make an accurate judgment about one’s own performance. The mental math exercise was chosen over a test of some other type of math because it is rare that we are tested or evaluated on our ability to mentally solve arithmetic problems. Thus, a person might know from previous experience and/or the results of standardized testing that he/she is far above average in algebra. However, most people do not have similar standards of comparison for their ability to mentally solve arithmetic problems. Thus, this decreased the likelihood that the participants would question the validity of the false math feedback.

**Group composition manipulation.** The verbal feedback served as the group composition manipulation. To form homogeneous groups, the feedback was manipulated so as to suggest that all of the group members’ scores clustered closely together. In this case, group members 1, 2, and 3 were told that they scored in the 78th, 74th, and 76th percentiles respectively. In contrast, to form heterogeneous groups, the feedback was manipulated to suggest that the group members differed markedly in their performance on the verbal task. Group members 1, 2, and 3 were told that they scored in the 91st, 72nd, and 59th percentiles respectively.

The math feedback was held constant across conditions. The feedback showed that group members 1, 2, and 3 scored in the 56th, 59th, and 62nd percentiles respectively. The purpose of this feedback was to reduce suspicion about the reason for the verbal feedback that served as the group composition manipulation. This feedback was also included so that the group members had the option of focusing on some other type of information other than that which served as the experimental manipulation. Each workstation always corresponded to the same group member number and the same feedback. Although this was static, however, there was random assignment to the different types of feedback in the sense that participants were randomly assigned to each of
the respective workstations. The participants were given 30 s to view both the verbal and math feedback.

*Coordination requirement manipulation.* After participants received the feedback about their own and their other group members’ performance on both of the individual tasks, they then viewed the instructions for the group word recall task for 5 min. In the instructions, participants were told that the goal was for their group to successfully recall as many of the words from the lists presented as possible. In the matching condition, the instructions explained that for every word from any of the lists that a group member successfully recalled, the group would receive one point. In addition, if more than one person in the group successfully recalled the same word, then the group would get one point for both words plus an extra point for matching (i.e., a matching bonus). In the mismatching condition, groups were also told that they would receive one point for each word that one of its group members successfully recalled. However, if more than one group member recalled the same word, one point would be deducted for each time a word was repeated (i.e., a matching penalty). In other words, the penalty canceled out the contribution of the second group member recalling the same word. Thus, in the mismatching condition, a match between the responses of group members represents a waste of group effort. At this stage, the participants also were informed about the monetary prizes that were available to the best performing groups. These prizes were included to help ensure that participants were highly motivated to perform well on the task.

The groups then went on to complete the first trial of the group recall task. This task was iterated 10 times to allow for the assessment of changes in tacit coordination over time (i.e., in-process tacit coordination; Wittenbaum et al., 1998). Pretesting revealed that 10 trials was about the maximum number of trials whereby participants were still able to stay focused and engaged in the task. After each trial, participants received feedback about their group’s performance as a whole on the previous trial. This feedback accurately reflected the group’s actual performance. The feedback gave the total group score for that trial as well as the aggregated time that the group spent as a whole viewing each of the three lists. Viewing time was included to give the groups some means of using the feedback to improve in their ability to coordinate over time. The group score does not provide any information about how the group members actually behaved on the previous trial. This is because the group score is a function of both the number of words that the group recalled as a whole and the number of times that the group successfully coordinates. Therefore, viewing time enabled the participants to have some idea of what the other group members were doing. No feedback was provided about individual performance for two reasons. First, this would have rendered the feedback cumbersome and confusing. Second, feedback about the individual group members could have interfered with the group composition manipulation. This is because if a group member’s performance on the word recall task does not mesh with the score that was provided in the feedback for the group composition manipulation, the participants may begin to doubt the validity of the false feedback, and thus this could undermine the success of the manipulation.

After completing all 10 trials of the group recall task, participants completed the remaining measures. These measures asked the participants to make Likert ratings for a number of statements related to the task and the feedback with which they had been provided in the experiment. They were then debriefed and thanked for their participation. In the debriefing, the participants were made aware of the prior deceptions and were provided with an accurate record of the number of items they had gotten correct for each of the two individual tasks. They were
also reminded that they would be notified at the end of the semester if their group won one of the available monetary prizes.

Results

 Manipulation Checks

 Coordination requirement. As a manipulation check, the total number of matches made by groups in the matching condition was compared to the total of those made by groups in the mismatching condition. A match was counted every time two group members correctly recalled the same word from any of the three lists that had appeared on that given trial. If all three group members correctly recalled the same word, this was counted as three two-way matches. This is because in this case the first group member matches both the second and third group members and the second and third group members also match with each other. If a group member reported the same word more than once, these duplicates were removed prior to calculating both the number of words correctly recalled and the number of matches that were made by the group. Groups in the matching condition matched more frequently across trials ($M = 104.53$, $SD = 41.20$) than groups in the mismatching condition ($M = 63.50$, $SD = 29.33$), $t(56) = 4.34$, $p < .001$. This suggests that the participants accurately understood the directions that described how their groups were asked to coordinate.

 Group Composition. Each participant was asked to give a rating for the item “To what extent did you perceive you and your other group members to be similar in terms of ability to memorize and recall words?” on a scale ranging from 1 (Not Very Similar) to 9 (Very Similar). If the group composition manipulation (using the false verbal feedback from the verbal task) had the intended effect, then the participants in the homogeneous groups should have given higher ratings for this statement than those in the heterogeneous groups. Because the participants made their ratings after they had worked together in groups, the individual ratings of the participants within each group could no longer be treated as independent of one another (see Moritz & Watson, 1998). Therefore, to avoid violating the statistical assumption of independence, a mean was taken for the individual ratings within each group, and then a group-level analysis was conducted using these mean ratings. The mean ratings were then submitted to a $2 \times 2$ (coordination requirement: matching vs. mismatching) x $2$ (group composition: homogeneous vs. heterogeneous) between-groups analysis of variance (ANOVA). This analysis revealed that there was no difference in the mean ratings for the homogeneous ($M = 5.75$, $SD = 1.53$) and heterogeneous ($M = 5.69$, $SD = 1.89$) groups, $F(1, 54) = 0.77$, $p = .39$, $\eta^2 = .01$. The other effects also were not significant, all $Fs < 1.03$, all $ps > .31$. Although this suggests that the manipulation was not successful, a possible reason for this finding is that the impact of the manipulation may have been diluted as a result of the additional feedback that the group members received as they worked together over the trials of the word recall task. For this reason, the feedback on the word recall task was provided in aggregate at the group level, and no information was provided about the behavior or performance of any of the specific individuals within the group. Despite this effort, however, it is possible that this additional feedback still interfered with the earlier verbal feedback that served as the group composition manipulation.
Coordination Index

Formula. A coordination index was developed that measured a group’s coordination efficiency on each trial of the word recall task. This index is defined by the following formula:

\[ c_i = \frac{m_i}{2r_{fi} + r_{ni}} \]

In the above formula, \( c_i \) represents the coordination index for the \( i \)th trial, \( m_i \) represents the total number of times the group members matched on that trial, \( r_{fi} \) represents the number of words reported by the individual in the group who recalled the fewest words on that trial, and \( r_{ni} \) represents the number of words reported by the group member who recalled the next-to-fewest number of words on that trial. In all cases, a correct response was counted only if the word reported was spelled correctly and had appeared on one of the three lists from that trial. The number of matches for the numerator of the formula was calculated in the same way as described above for the manipulation check.

If we consider Steiner’s (1972) model of group performance and then apply this more specifically to coordination, the numerator of the formula for the coordination index can be conceptualized as the group’s actual coordination success because this represents the number of times that the group actually was able to coordinate by giving matching responses. This is analogous to what Steiner (1972) referred to in his model as the group’s actual productivity. On the other hand, the denominator of the formula is intended to represent the group’s potential for coordination success given the limits imposed on this by the individual differences in the group members’ abilities and motivation to perform well on the task. The number of words that the individuals in the group are able to accurately recall on any given trial places an upper limit on the number of times that the group can coordinate successfully. Thus, perfect coordination (in terms of matching) would be achieved when every response given by the group member who accurately recalled the fewest words on a given trial matched one of the responses given by each of the other two group members (\( r_{fi} \)). In addition, perfect coordination also requires that every response given by the group member who accurately recalls the next-to-fewest words on that trial match one of the responses given by the best-performing group member (\( r_{ni} \)). This is because every response given by a worse performing group member could potentially match every response given by a better-performing group member but not vice versa. In Steiner’s (1972) model, the denominator of the formula for the coordination index is analogous to the group’s potential productivity.

Assumptions. Deriving the formula to represent the group’s potential coordination success requires making at least two assumptions. First, this argument assumes that all of the words are interchangeable in terms of ease of recall. That is, for every specific word that any given participant recalls, the assumption is that he/she was equally capable of recalling any of the other words from the three lists on that trial. Evidence for this assumption comes from the fact that the words were chosen so that they were similar on a variety of dimensions potentially related to ease of recall based on norms compiled by Toglia and Battig (1978). The other assumption is that every individual in a given group was motivated to maximize his/her own recall and did not try to limit the responses given in order to avoid coordination failure with the other group members. In general, this was not a rational strategy because the only way a correct response could ever have been to the group’s detriment was when all three group members
matched in the mismatching condition. In this instance, one point would be awarded to the group for each group member correctly recalling the word and then one point would be deducted for each match resulting in a net gain of zero. If one of the group members had not reported the word (even if they remembered it), then the group would have gotten a point because then there would have only been one match instead of three. However, this scenario is probabilistically unlikely, and it is doubtful that the participants would have been this analytical in assessing the way the points were allocated. Furthermore, the directions only explained the rules for how the points were allocated in a two-way match and did not explicitly address how the points would be scored in the case of a three-way match. Thus, the directions would have suggested that it was always to the group’s benefit for everyone in the group to report as many of the words as they could recall. However, although a motivational bias was unlikely given the way the points were awarded to the group, this is a critical assumption in that the formula assumes that the number of words each group member reports on any given trial is the maximum number of words that he/she is capable of accurately recalling on that trial. Thus, if he/she is somehow motivated to avoid reporting a specific word even though he/she remembered the word, then this could potentially bias the estimate of the group’s potential coordination efficiency for the denominator of the coordination index because the number of words reported is no longer an accurate measure of the number of words in general that he/she was capable of recalling. However, although a motivational bias was unlikely given the way the points were awarded to the group, this is a critical assumption in that the formula assumes that the number of words each group member reports on any given trial is the maximum number of words that he/she is capable of accurately recalling on that trial. Thus, if he/she is somehow motivated to avoid reporting a specific word even though he/she remembered the word, then this could potentially bias the estimate of the group’s potential coordination efficiency for the denominator of the coordination index because the number of words reported is no longer an accurate measure of the number of words in general that he/she was capable of recalling.

Interpretation. The coordination index is a ratio of the number of coordination successes to the number of attempts or potential opportunities to coordinate with a possible range from zero to one. Therefore, the index can be interpreted as the percentage of the time the group is successfully coordinating. However, this is only the case in the matching condition (where successful coordination is defined as two or more group members providing matching responses). In the mismatching condition, the criterion for successful coordination is exactly the opposite (i.e., the group members are trying to coordinate by not duplicating responses). Therefore, so that higher numbers would have the same interpretation in both the matching and mismatching coordination conditions (in terms of higher numbers representing more efficient coordination), the coordination index was reversed scored in the mismatching condition by subtracting the formula presented above from one. Because of this, in the mismatching condition, the coordination index represents the percentage of the time that group members mismatched given the potential number of times they could have failed to coordinate by matching. In both the matching and mismatching conditions, however, the coordination index has the same interpretation in the sense that it represents the percentage of the time that the group coordinated successfully under the coordination requirement that the group was given.

Coordination Efficiency

For every group, the coordination index was calculated separately for each of the 10 trials of the word recall task. These results were then submitted as the dependent measure in a 2 (coordination requirement: matching vs. mismatching) x 2 (group composition: homogeneous vs. heterogeneous) x 2 (block: trials 1-5 vs. trials 6-10) mixed-model ANOVA with the first two factors manipulated between groups and the last factor as a repeated measure. An additional analysis was performed with the order of completion and feedback presentation for the two individual tasks (verbal task first vs. math task first) and participant type within group (all volunteer vs. all paid vs. mixed) entered as additional between-groups factors. As
limited power resulting from a small sample size (14 to 15 groups per condition), all tests of a
priori hypotheses for the coordination index were treated as one-tailed unless otherwise noted.
There was a significant and predicted two-way interaction between the coordination requirement
and group composition factors, $F(1, 54) = 2.75, p = .05, \eta^2 = .05$ (see Figure 1). To further
explore this interaction, planned contrasts were used to test specific hypotheses. In the matching
condition, the predicted trend emerged such that homogeneous groups ($M = .43, SD = .16$) were
able to coordinate more efficiently than heterogeneous groups ($M = .37, SD = .11$). For the
mismatching condition, there was also a trend in the predicted direction such that heterogeneous
groups ($M = .78, SD = .09$) coordinated more efficiently than homogeneous groups ($M = .74, SD
= .07$). Although the means trended in the predicted directions in both cases, planned contrasts
revealed that neither of these differences was significant ($F(1, 54) = 0.94, p = .17$, and $F(1, 54) =
0.48, p = .25$, respectively). As predicted, there was a highly significant main effect of trial block
indicating that groups coordinated more efficiently during the last half ($M = .62, SD = .25$) than
the first half ($M = .53, SD = .21$) of the trials, $F(1, 54) = 20.18, p < .001, \eta^2 = .27$. This suggests
that groups improved in their ability to coordinate over time. There was also a main effect of the
coordination requirement, $F(1, 54) = 151.87, p < .001, \eta^2 = .74$, two-tailed. Overall, groups were
better at coordinating by mismatching ($M = .76, SD = .08$) than by matching ($M = .40, SD = .14$).
This difference can be explained by differences in the structure of the two tasks. Due to the large
number of words across the three lists, the probability of matching by chance is much lower than
mismatching by chance. Thus, there is a probabilistic advantage for groups trying to coordinate
in the mismatching condition. No other significant results emerged, all $Fs < 0.60$, all $ps > .44$.

**Distribution of Viewing Time**

In order to provide further support for the analyses conducted on the coordination index,
a secondary set of analyses was performed looking at the way the groups distributed their
viewing time across the three word lists on each trial of the word recall task. To do this, the time
spent viewing each of the three word lists on each trial was aggregated across the three members
of the group. A standard deviation then was calculated for these three values as a measure of the
variability in the time that the group allocated to viewing each of the lists. A larger standard
deviation indicates that the group spent more time viewing one list, whereas a smaller standard
deviation indicates that they distributed viewing time more evenly across the three lists. This is
because the more time a group spends viewing a particular list, the more the value for the time
spent on this list will be an outlier from the other two values for the time spent viewing the other
two lists resulting in a relatively large standard deviation. On the other hand, if the group
distributes viewing time approximately equally across all of the lists, then all three values will be
closely clustered around the mean resulting in a relatively small standard deviation.

eXpected, none of the main effects or interactions with these two factors were significant, all $Fs <
3.58, all ps > .07$. Therefore, these factors were excluded from subsequent analyses. Otherwise,
this analysis yielded the same pattern of results as those reported except for the Coordination
Requirement x Group Composition interaction was no longer significant, $F(1, 41) = 1.03, p =
.16, \eta^2 = .02$, one-tailed. This difference between the two analyses is due to the loss of power
resulting from the additional degrees of freedom required for the main effects and all possible
interactions involving the two additional between-groups factors.
Because the dependent measure has two different interpretations for the two types of tasks (matching vs. mismatching), the analyses on the data for viewing time were done separately for each level of the coordination requirement. In the matching condition, a larger standard deviation represents a more optimal allocation of viewing time, whereas, in the mismatching condition, a smaller standard deviation represents a more optimal allocation of viewing time. Because the dependent measure has opposite interpretations depending on the coordination requirement, any interaction involving the coordination requirement factor would not have a meaningful interpretation. Also, reverse scoring was not possible because there is no fixed upper limit on the size of the standard deviation.

For the matching condition, a 2 (group composition: homogeneous vs. heterogeneous) x 2 (block: trials 1-5 vs. trials 6-10) mixed-model ANOVA with the first factor manipulated between groups and the last factor as a repeated measure revealed a significant interaction, $F(1, 28) = 5.98, p = .02, \eta^2 = .18$. To further explore this interaction, separate repeated measures ANOVAs were conducted for both levels of the group composition factor (see Howell, 2002). For the homogeneous groups, there was a main effect of block such that the standard deviations increased from Block 1 ($M = 64.92, SD = 22.67$) to Block 2 ($M = 92.44, SD = 34.43$), $F(1, 14) = 14.29, p < .01, \eta^2 = .51$. This suggests that over time the homogeneous groups learned to allocate their viewing time more effectively across the lists. There was no significant effect for the heterogeneous groups, $F(1, 14) = 1.85, p = .20, \eta^2 = .12$. This suggests that they did not improve in their ability to allocate their viewing time from Block 1 ($M = 51.31, SD = 17.07$) to Block 2 ($M = 57.67, SD = 23.52$). For the mixed-model ANOVA, there was also a main effect of the group composition factor, $F(1,28) = 8.85, p < .01, \eta^2 = .24$. Overall, the homogeneous groups ($M = 65.91, SD = 3.47$) had larger SDs than the heterogeneous groups ($M = 52.06, SD = 3.47$) suggesting that the homogeneous groups allocated their viewing time more efficiently. There was also a main effect of block, $F(1, 54) = 15.33, p = .001, \eta^2 = .35$. The SDs increased from Block 1 ($M = 58.11, SD = 20.90$) to Block 2 ($M = 75.06, SD = 33.94$) suggesting that overall groups learned to allocate their viewing time more efficiently over time.

For the mismatching condition, a 2 (group composition: homogeneous vs. heterogeneous) x 2 (block: trials 1-5 vs. trials 6-10) mixed-model ANOVA with the first factor manipulated between groups and the last factor as a repeated measure revealed only a main effect for block, $F(1, 54) = 5.37, p = .03, \eta^2 = .17$. The SDs decreased from Block 1 ($M = 56.10, SD = 16.03$) to Block 2 ($M = 46.76, SD = 18.58$) suggesting that over time groups improved in the efficiency with which they allocated viewing time. The other effects were not significant, all $Fs < 1.29$, all $ps > .26$.

Post-Experimental Questions

After the participants completed the word recall task, they were asked to make Likert ratings for statements designed to assess their perceptions of the different aspects of the experiment. Because the participants made their ratings after they had worked with their groups, the mean of the individual ratings within each group served as the dependent measures in all analyses. As previously discussed, this was done in order to maintain independence in the unit of analysis. These mean ratings were analyzed in a series of 2 (coordination requirement: matching vs. mismatching) x 2 (group composition: homogeneous vs. heterogeneous) between-groups ANOVAs.
Perceived coordination success. Participants were asked to rate the statement “How effectively did your group coordinate?” on a scale from 1 (Not Very Effectively) to 9 (Very Effectively). The ANOVA revealed no differences across the experimental conditions in the within-group mean ratings, all Fs < 1.21, all ps > .27. In addition, the participants also were asked to rate “How difficult was it for your group to coordinate in order to optimize its performance on the word recall task?” on a scale ranging from 1 (Not Very Difficult) to 9 (Very Difficult). Once again, the ANOVA showed no significant effects, all Fs < 2.59, all ps > .11. One reason for why no differences were found across conditions for the mean ratings from either of these two statements could be because the participants were provided with feedback about their group’s actual performance after every trial of the word recall task. Because of this, their perceptions of their groups’ ability to coordinate may have been more influenced by the performance feedback they received than by the condition that they participated in. Indeed, mean ratings for both statements were significantly correlated with the group score feedback from the last trial of the word recall task, r = .35, p < .01, and r = -.26, p < .05, respectively. For the former statement, a positive correlation indicates mean ratings that are consistent with the group score feedback, whereas the reverse is true for the latter statement. Thus, these results are consistent with the argument that the participants attended to the performance feedback that they were provided with in assessing their groups’ ability to successfully coordinate.

Verbal feedback. Prior to beginning the word recall task in groups, the participants had been given feedback about each group member’s individual performance on an analogies task (which they were told assessed verbal ability). In order to assess the extent to which the participants attended to this feedback, they were asked to rate both “How much attention did you give the feedback presenting your performance on the verbal (analogies) test in deciding how to allocate your effort on the word recall task?” and “How much attention did you give the feedback presenting your other group member's performance on the verbal (analogies) test in deciding how to allocate your effort on the word recall task?” on scales ranging from 1 (Not Very Much) to 9 (A Great Deal). Mean ratings for both of these statements were internally consistent (α = .89), thus these items were combined into a composite scale. There was a significant main effect of group composition such that the participants in heterogeneous groups (M = 4.29, SD = 1.17) reported attending more to the verbal feedback than those in homogeneous groups (M = 3.66, SD = 1.27), F(1, 54) = 3.90, p = .05, η² = .07. One reason for this difference may have been that the verbal feedback was more informative for the heterogeneous than the homogeneous groups. In the homogeneous groups condition, the participants are led to believe that they all performed similarly to one another. However, they do not have any feedback about their actual performance, and thus it is difficult for them to know for example if they all performed well or did poorly. All they are provided with are percentile rankings that they are told are normed to a nationally representative sample of American college students. In contrast, for the heterogeneous groups condition, the feedback provides more information because they are given information about how well everyone in their group did relative to everyone else, which is more informative than only knowing that everyone in your group is similar to one another relative to a standard that is not specifically defined.

Math Feedback. In addition to the verbal feedback, the participants also received feedback about each group members’ individual performance on a math task. To evaluate the extent to which the participants attended to this feedback, they were asked to rate both “How much attention did you give the feedback presenting your performance on the math test in deciding how to allocate your effort on the word recall task?” and “How much attention did you
give the feedback presenting your other group member’s performance on the math test in
deciding how to allocate your effort on the word recall task?” on scales ranging from 1 (Not
Very Much) to 9 (A Great Deal). The mean ratings for both of these statements were combined
into a composite scale (α = .84). There were no differences across conditions, all Fs < .37, all ps
> .54. No differences were expected because this feedback was held constant across all
conditions in the experiment. The verbal feedback served as the manipulation of the group
composition factor, and the math feedback was included to lessen demand and so that the group
members would have some kind of additional information about everyone in their group (other
than that provided as part of the experimental manipulation) that they could potentially use in
trying to coordinate with one another.

An additional analysis was conducted comparing the composite scale ratings for both the
verbal feedback and the math feedback. This revealed that across conditions mean ratings were
higher for attending to the verbal feedback (M = 3.97, SD = 1.25) than for attending to the math
feedback (M = 3.48, SD = 1.40), t(57) = 3.12, p = .003. One reason for this could be that as
intended the participants may have recognized that the verbal feedback was more relevant than
the math feedback for coordinating on the word recall task.

Motivation. As a measure of motivation to perform the task, participants were asked to
rate “How much effort did you put into memorizing the words?” on a scale ranging from 1 (Very
Little) to 9 (A Great deal). There was a significant main effect of the coordination requirement,
F(1, 54) = 4.25, p = .04, η² = .07. When analyzed at the group level, participants reported greater
individual motivation to perform the task in the matching (M = 8.23, SD = 0.57) than in the
mismatching condition (M = 7.85, SD = 0.81).

Discussion

Summary of Findings

Manipulation checks. Although there was strong support for the success of the
coordination requirement manipulation, the other check suggested that the group composition
manipulation may not have been successful. As previously discussed, this may have occurred
because the impact of the feedback that served as the group composition manipulation may have
been diluted as a result of the additional feedback that the participants received at each stage as
they worked together with the rest of their groups on the word recall task. However, Wittenbaum
et al. (1996) made a related finding in an experiment that used a similar paradigm without
iterative trials and without additional trial feedback. In this case, although their results suggested
that the group members differentially allocated their attention to different parts of the task, the
participants’ reports did not reflect the use of such strategies. Instead, their results suggested that
the participants reported giving equal attention to all parts of the task. Thus, the manipulation
check may not have been successful because the group composition feedback could have had an
effect on a nonconscious level that the participants were not able to accurately report. The speed
and ease with which tacit coordination appears to develop as well as the failure of participants to
accurately report on the use of these strategies may indicate that tacit coordination is primarily a
nonconscious process (Wittenbaum et al., 1996). This also could help to explain how an existing
tacit coordination system can interfere when an explicit coordination rule is arbitrarily assigned
(Camerer, 2003; Wegner et al., 1991). That is, it may be the case that tacit coordination (a
relatively automatic process) interferes with explicit coordination (a relatively conscious process)
when the cognitive resources and/or motivation needed to follow the explicit coordination rule are inadequate. However, as Wittenbaum et al. (1996) point out, their results are merely suggestive and do not provide any definitive evidence that tacit coordination is a nonconscious process. One alternative explanation is that the participants may have been aware of the strategies that they used but then reported attending equally to all parts of the task because that is what they thought they should have done. In addition, caution should be exercised in applying Wittenbaum et al.’s (1996) interpretation to the results of this particular study. Unlike Wittenbaum et al. (1996), the results of the current study only partially support the hypotheses for how the group composition feedback should contribute to coordination success. Thus, the evidence does not strongly suggest that the participants were able to use this feedback to develop highly successful strategies to begin with.

Coordination index. The analyses for the coordination index partially supported the main hypotheses. The overall interaction was significant and all of the means trended in the predicted directions. The trend was for the homogeneous groups to coordinate more effectively than the heterogeneous groups in the matching condition and vice versa for the mismatching condition. However, the predicted simple effects did not approach significance. Thus, while these analyses were sympathetic to and somewhat supportive of the hypotheses, the strongest support would have been obtained if the simple effects as well as the overall interaction had attained significance. One limitation that may have contributed to the lack of conclusive results may have been the limited power available given the number of groups that were able to be run in each condition. However, the test of the primary hypotheses in terms of the Coordination Requirement x Group Composition interaction collapsed across two blocks of 10 trials of a repeated measure. Although the degrees of freedom were limited by the sample size for the analysis of the between-groups effects, collapsing across the repeated measure should have resulted in more stable means than looking at an individual trial of the word recall task alone and thus should have helped to compensate for the limited power. Another important factor is that the interaction was a small effect ($\eta^2 = .05$). Thus, combined with the limited power, this also made it more difficult to detect the predicted effects.

Overall, the results clearly supported the hypothesis that groups are able to improve in their ability to coordinate over time. Regardless of the condition the groups were in, they learned to coordinate more efficiently from the first block to the second block of the trials of the word recall task. Thus, this provides evidence of successful in-process tacit coordination. Groups were able to use the feedback and their experience working together on the task to develop more effective and efficient tacit coordination strategies over time.

Distribution of viewing time. The results for the distribution of viewing time across the lists were mixed. When differences were found they were congruent with what would be expected given the hypotheses as well as supportive of the results found for the coordination index. In the matching condition, homogeneous groups appeared to improve in their ability to focus their viewing time on the word recall task, whereas the heterogeneous groups did not. Also, overall there was a main effect for the matching condition such that all groups improved in their ability to focus viewing time over the two trial blocks. In the mismatching condition, rather than focusing their time, the groups would have been expected to divide their time equally between viewing the three lists if they had developed a successful coordination strategy. Consistent with this idea, the groups in the mismatching condition improved in their ability to distribute viewing time between the three lists across the two trial blocks. These data would have been more supportive of those for the coordination index if the heterogeneous groups had been
able to distribute their viewing time more efficiently than the homogeneous groups. Thus, although some of the expected results were not significant, none of the results were contradictory to the findings reported for the coordination index.

In addition, the dependent measure has several limitations that could potentially explain why these results did not more clearly support the results obtained with the coordination index. First, recall that each of three lists appeared on the computer screen one at a time and that each group member could select any list and move between them as often as desired by selecting one of the three option buttons corresponding to each list. Initially, none of three lists were visible, and, at the start of each trial, each group member had to select one of the three option buttons to begin viewing one of the lists. Thus, viewing time was measured from the time a participant clicked the button for one of the lists up until he/she clicked one of the other buttons for the other lists or until the time ran out. If the participant viewed a list more than once during the same trial, then the time they spent viewing that same list each time were summed on each trial. A problem with this is that a participant can select a list, but this does not necessarily mean that they are actively focusing on studying the words on that list during the entire time or even any of the time that the list is selected. For example, a participant might click one of the three buttons at the beginning of a trial so that one of the lists is visible but then not attend at all to the task or the words on the list. Thus, this is a less than totally accurate way of assessing the amount of time that each group member is focused on and actively engaged in studying the words on each of the three lists. The other issue is that there is a unit of analysis problem. Prior to calculating the standard deviation for each trial, the time that each group member spent looking at each of the three lists is aggregated and summed. Thus, it is difficult to determine the extent to which the standard deviation is being influenced by the individual behavior of a single group member versus the degree to which it is influenced by all three of the group members acting together as a group. For example, if one group member initially chose any one of the lists and then never switched to a different list or switched very little while at the same time the other two group members switched often and behaved randomly, the standard deviation would give the appearance that the group was doing very well at focusing its viewing time on a single list even though this was being driven for the most part by the individual behavior of one participant independent of what the rest of the group was doing. This is because the list that the one group member spent most of their time on would become an outlier to the times the group spent viewing the other two lists, therefore resulting in a relatively large standard deviation. It is possible that more of the results for viewing time would have been consistent with those for the coordination index if a better measure of the way the groups allocated their efforts had been available.

Use of Feedback and Coordination Success

In order to successfully use feedback as a coordination cue, it is critical that all of the group members both attend to the feedback and interpret it in the same or a very similar way. If one group member ignores the feedback or interprets it differently from the rest of the group, then this results in a predicament. Should the other group members continue to follow the same coordination strategy based on the feedback, or should they abandon this strategy to try to accommodate the behavior of the wayward group member? Two additional factors may further aggravate this problem. The first is related to group size. As group size increases, the probability also increases that at least one of the group members will deviate from following the
coordination strategy implied by the feedback. Furthermore, in larger groups, there is a high likelihood that two or more of the group members will deviate from a strategy based on the feedback. In this case, if both of these group members are behaving in different ways, it may be particularly difficult for the rest of the group to develop a new coordination strategy that incorporates the deviant group members. Also important is whether or not a deviant group member follows a consistent strategy of some kind. If the deviant group member behaves randomly, then it will be nearly impossible for the other group members to change their strategy in a way that accommodates what the deviant group member is doing. If the deviant group member follows a consistent strategy, however, then the rest of the group may still be able to learn to coordinate effectively by abandoning their use of the feedback and instead trying to follow the strategy that the deviant group member appears to be using. The difficulty of incorporating a group member who follows an alternative strategy from the rest of the group will vary depending on how the group needs to coordinate. If the group is matching, assuming that the deviant group member is behaving consistently, then developing a new successful coordination strategy is just a matter of shifting to the same subtask that the deviant group member is already focusing on. However, the problem is more difficult when the group is coordinating by mismatching. In this case, the deviant group member is displacing one of the other group members from the subtask that the feedback implied that they should be doing. Thus, it is unclear whether the displaced group member should switch to the now unclaimed subtask or (in the case of a three-person group) whether both of the other group members should switch. For example, if the group member who the feedback suggested should do the most difficult subtask instead chooses the easiest subtask, should the group member who the feedback suggested was the least competent now switch to the most difficult subtask, or would it be better for both group members to switch so that the least competent group member is now doing the intermediate subtask and the intermediate group member is now doing the most difficult subtask? In this case, the problem is much more difficult because while the latter is probably the more rational strategy, it again requires that both group members attend to and reinterpret the feedback in the same way given the behavior of the deviant group member. In addition, it is difficult to predict which of the two strategies another person is likely to follow, and this problem will become even more difficult as group size is expanded. Thus, when one group member violates a norm, it will be much easier for the rest of the group to develop a new strategy that accommodates this behavior in the matching than in the mismatching condition.

Future Directions

One limitation to the current study is that the participants were not directly asked how relevant they saw the verbal feedback from the analogies task to the ability to memorize and recall words on the word recall task. The manipulation check alludes to this point, but, in future research, it would be beneficial to ask participants about the way they viewed the diagnosticity of the group composition feedback more directly. In addition, further research with additional groups would help to increase power and thus possibly further clarify these results. The addition of a control group is also an interesting possibility because this would allow a more direct assessment of whether having a group composition that is congruent with the task facilitates coordination or if having a group composition that is incongruent with the task hinders and inhibits coordination. Given that the interaction was of the crossover type and not a fan effect, my hypothesis would be that the effect is probably being driven mostly by facilitation resulting
from having a group who’s composition maps on more easily to the task provided. For example, if the effect was predominantly due to inhibition resulting from thinking everyone is different with regards to the skill required by the task in the matching condition, then I would expect that there would be no difference for group composition in the mismatching conditions. It is also possible that the interaction is the combination of a sum of both facilitation and inhibition effects.

Another interesting question is the importance of feedback relevance. For example, is it necessary for the participants to see the performance on the individual verbal task as relevant to word recall in order for this information to serve as a useful coordination cue, or will the group still use this information even if the feedback itself is judged to be irrelevant to the word recall task? In the extreme case, this could involve providing the group members with feedback that only identifies each one as high, medium, or low respectively. In the lack of other information, it is possible that this information might enable the group to develop a shared strategy for how to approach the task. For example, in the mismatching condition, everyone in the group might assume that the group member labeled high will take the most difficult list despite the fact that the feedback itself is no way diagnostic of any of the group members’ abilities to recall words. Future research will be necessary to address these possibilities.

Conclusion

The findings provided strong support for the ability of groups to develop modes of coordination over time without the need for overt communication. Although there was some support for this process being affected by differences in group composition, further research will be needed before a definitive conclusion can be reached as to whether differences in the relative abilities of group members impact the development of tacit coordination. Specifically, more research is needed to determine whether tacit coordination is enhanced when there is congruence between the composition of the group and the coordination requirement of the task that they are given.
Figure 1. The Effects of Group Composition and the Task Structure on Coordination Efficiency
References


APPENDIX A

Sample Miller Analogies Test (MAT) Items for the Individual Verbal Task

Note: Items are listed in the order that they were presented to the participants. The items originally appeared in Bader, Burt, and Killoran (2001).

1. BALMY : MILD :: FATIHFUL (A. explosive, B. docile, C. talkative, D. staunch)
2. BOLD : TIMID :: SQUANDER : (A. disperse, B. hoard, C. query, D. extinguish)
3. SEA : (A. fish, B. ocean, C. island, D. net) :: LAND : LAKE
4. GLASS : RUBBER :: BRITTLE : (A. elastic, B. scarce, C. tempered, D. spheroid)
5. GLABROUS : FACTITIOUS :: HIRSUTE : (A. authentic, B. fictional, C. fluent, D. replete)
6. PARANOIA : SCHIZOPHRENIA :: MEGALOMANIA : (A. melancholia, B. carcinoma, C. hepatitis, D. glaucoma)
7. (A. sales, B. investment, C. management, D. interest) : PROFIT :: LABOR : WAGES
8. STUDENT : (A. backpack, B. briefcase, C. college, D. teacher) :: TRAVELER : SUITCASE
9. DENIGRATE : DEFAMER :: MEDIATE : (A. mathematician, B. arbitrator, C. employer, D. laborer)
10. LAKE WOBEGON : (A. Minneapolis, B. Winesburg, C. Canterbury, D. Minnesota) :: MUDVILLE : CASTERBRIDGE
11. CORNET : OBOE : (A. cello, B. drum, C. harpsichord, D. xylophone) : GUITAR
12. JANUARY: WEDNESDAY :: JANUS : (A. Thor, B. Apollo, C. Odin, D. Diana)
13. HORSE : (A. equestrian, B. hoofed, C. cabriolet, D. herbivorous) :: TIGER :
    CARNIVOROUS
14. GOOD : BETTER :: (A. terrible, B. worse, C. improvement, D. bad) : WORST
15. CLAN : FEUD :: NATION : (A. war, B. politics, C. armaments, retaliation)
16. ABUNDANCE : ABROGATE :: DEARTH : (A. deny, B. establish, C. abstain, D. absolve)
17. ONOMATOPOEIA : MATEPHOR :: SOUND : (A. hiss, B. rhyme, C. saying, D. comparison)
18. SACRAMENTO : HELENA :: ALBANY : (A. New York, B. Little Rock, C. Houston, D. San Francisco)
19. (A. scan, B. feel, C. dear, D. seen) : READ :: REAP : PEAR
20. CAUTIOUS : CIRCUMSPECPT :: PERCIPITOUS : (A. premonitory, B. profound, C. stealthy, D. steep)
21. SEISMOGRAPH : GEOLOGY :: ELECTROENCEPHALOGRAPH : (A. bacteriology, B. biology, C. neurology, D. cardiology)
22. ACUTE : VENERATE :: CHRONIC : (A. reverse, B. actuate, C. flout, D. repent)
23. (A. toad, B. lion, C. shark, D. alligator) : TURTLE :: TIGER : HUMAN
24. INSTINCT : PLAN :: UNCONSCIOUS : (A. involuntary, B. intentional, C. spontaneous, D. imaginary)
25. INDIA (A. Sri Lanka, B. Greece, C. Afghanistan, D. Pakistan) :: ITALY : SWITZERLAND
26. SWIM : SWAM :: BURST : (A. busted, B. bursted, C. burst, D. bust)
27. RAISIN : GRAPE :: PRUNE : (A. apricot, B. currant, C. plum, D. berry)
28. BEAKER : CHEMIST :: STETHOSCOPE : (A. teacher, B. author, C. doctor, D. dentist)
29. LIMPID : LUCID : TURBID : (A. torpid, B. muddy, C. truculent, D. serene)
30. MANGO : (A. coconut, B. tomato, C. cabbage, D. apple) :: PAPAYA : PASSIONFRUIT
APPENDIX B

Problems for the Individual Math Task

Note: Problems are listed in the order that they were presented to the participants. The math problems originally appeared as part of a mental math test on the following website: http://www.okcupid.com/tests/take?testid=14948377049710579767

1. 1789 + 902 + 4007 + 92 = (6600, 7000, 6800, 6700)
2. 10000089 + 10000099 + 10000002 = (300001090, 300000190, 300000200, 300001900)
3. 3333 + 3333 + 3333 = (10000, 100000, 1000, 10009)
4. 0.75 + 0.5 + 0.25 = (1 3/4, 1.50, 2.00, 3/4)
5. 3/4 + 1/2 + 1/4 = (1 3/4, 1.50, 5/4, 3/4)
6. 10000 - 9989 = (1, 21, 10001, 11)
7. 5 - 1 - 5 = (0, 1, 9, -1)
8. 6895 - 129 - 1238 - 809 = (4519, 5400, 4600, 4700)
9. 1 - 1/2 - 1/3 = (0, 1/23, 5/6, 1/6)
10. 1 - .587 - .795 -.21 = (0, -0.5, 0.5, -0.6)
11. 123 * 126 = (12000, 14000, 15000, 126000)
12. 234590 * 11 = (2670590, 2345900, 2580490, 2499000)
13. 234590 * 101 = (23600000, 23700000, 23800000, 23900000)
14. 9999 * 43390 = (433900000, 999999999, 420000000, 399999999)
15. 97979 * 0.517 = (5000, 50000, 100000, 75000)
16. 1/2 * 1/4 * 1/10 = (0.1, 0.01, 0.08, 80)
17. 1/2 * 0.25 * 0.1 = (1/10, 1/100, 4/25, 80)
18. 100000 / 10000 = (10000, 99999, 10, 109999)
19. 91239084 / 989 = (91239, 92000, 100000, 10000)
20. 9000 / 0.75 = (6750, 7000, 6500, 12000)
21. 43095 / 23894 = (2, 1.8, 1.75, 1.70)
22. 22 / 7 = (3, 3.1, PI, 3.2)
23. Which is the best estimate of 0.4563748? (0.45, 0.46, 0.5, 0.4)
APPENDIX C

Word Lists for the Group Word Recall Task

**Trial 1**

10 words: HUT, TUBERCULOSIS, RAKE, ASPIRIN, TIE, NAVAL, WAFER, VASE, BARREL, OIL
15 words: SOD, ARMOR, GROIN, DRESSER, STRING, POLO, HAILSTONE, SOCK, TON, TEA, SOW, HOOD, MUTTON, SARDINE, CANTEEN
20 words: HOG, FRECKLES, FORCEPS, SKILLET, ASPARAGUS, POLLEN, CHAIN, BRAKE, SEAT, PURSE, SERGEANT, PORK, HEROIN, ARK, COPPER, WEB, SLUSH, KNUCKLE, SKUNK, SHILLING

**Trial 2**

10 words: GARDENIA, SOOT, BANDAGE, HANDGRENADE, JAIL, ICICLE, REFEREE, BRASS, INCENSE, DOUGH
15 words: COCKPIT, MAROON, SEAWEED, YOLK, WIG, CAULIFLOWER, BURLAP, THUNDER, SHAWL, VIOLET, MURDER, CEMENT, HEADBOARD, TOAD, MANURE
20 words: INK, HALL, OBESE, SODIUM, STEAM, ADMIRAL, HURRICANE, GRAVEL, BOOTH, GARBAGE, RAMP, SEAM, TOILET, ALLEY, TEST TUBE, IRON, CEREBRUM, TRAY, CURLER, DIAPERS

**Trial 3**

10 words: SWEAT, MULE, MANE, FAN, THERMOMETER, GUN, POLE, DENTIST, BOLT, SLEET
15 words: SCULL, WEED, BLEACH, MILE, HEEL, THIEF, ARMY, BEAN, ANT, PEN, FORK, STEEL, SNEEZE, BROOM, NEEDLE
20 words: CHINCHILLA, TURPENTINE, LOCKER, FISHHOOK, PIN, TWIG, ROD, GATE, BEE, SAUERKRAUT, DIAL, CUPBOARDS, BLACK, MOUSE, TRAILER, CABLE, REED, SPIDER, FOXTROT, SWORD

**Trial 4**

10 words: PLATE, CRABS, SHARK, TRIANGLE, SLIPPER, POTS, OVEN, HOOK, LIZARD, FLOOD
15 words: BASIN, CAGE, ALUMINUM, AMMONIA, CONCRETE, HOE, BONE, CANCER, WAX, PEDAL, THROAT, LINEN, CINDER, CLAMPS, CLOSET
20 words: STOOL, PELT, WAIST, OBOE, KETTLE, TOMB, SCALLOPS, SEMEN, SCARLET, DUKE, TACK, HARNESS, CHICKENPOX, CHISEL, SKULL, BAT, CRUCIFIX, COLLAR, HERMIT, GINGER

25
Trial 5

10 words: BUSH, SPONGE, PYTHON, KNOB, MUSTARD, FOG, OLIVE, MORPHINE, OYSTER, RUSTY
15 words: BADGE, SEAL, ONION, STOMACH, CARBON, PEG, JUGGLER, GRAY, SEWER, SUITE, PUDDLE, CEILING, HAMPISTER, BACTERIA, RAIL
20 words: STEEPLE, BEGGAR, HARDWARE, THIMBLE, RAINHAT, GRAVE, MUCUS, CORK, TICKET, PAUL, PAGE, CONVENT, CANNON, SPOON, EEL, MOSS, SHOVEL, WHIP, WIRE, GNAT

Trial 6

10 words: MARSHALL, MAYOR, SILK, ANCHOR, AUDITORIUM, TREASURER, BRICK, BATON, POPE, RUDDER
15 words: NAPKIN, PUPIL, CARP, JELLYFISH, CRUMB, CIGARETTE, SPEAR, CANOPENER, METAL, OAT, JOCKEY, CYMBAL, TAR, CENTS, CROCODILE
20 words: STOCKING, EARTHWORM, DAGGER, JACK, MAT, BEAK, GASKET, RAT, BOWL, HARP, PLOW, SHEEPSKIN, YOKE, LAP, ASH, HALLWAY, HELMET, TWIELER, TUSK, PIMPLE

Trial 7

10 words: CLARINET, STICK, CAROL, SCOOTER, SALT, DANDRUFF, FIDDLE, SACK, BASKET, SPATULA
15 words: EGG, DORM, GOAT, OREGANO, BISHOP, JAR, ROWBOAT, MINER, BASEMENT, HAZE, SKATE, SEAMAN, DUNGEON, NET, SCAR
20 words: SUIT, PANS, HAIRPIN, MOSQUITO, STEM, BRUSH, CIGAR, FLASHBULBS, TROLLEY, SAUCER, VEIL, BEET, RABBI, SPHERE, CAVE, PAPER, ICEBOX, SHELL, CORAL, PINT

Trial 8

10 words: HORN, CARDINAL, NAVEL, LUMBER, GRASSHOPPER, TOASTER, RAINCOATS, TUNNEL, VINEGAR, TUBE
15 words: TRAPEZE, STAIR, CURB, MONASTERY, DIMPLE, MEASLES, MAGNET, TAIL, CAPSULE, CORNER, KEROSENE, PENNICILLIN, DYE, BELLY, MORGUE
20 words: PIER, QUART, OAR, THREE, SINK, DISHWASHERS, MISSILE, DRIZZLE, TRAPEZOID, RECTANGLE, MOUTHPIECE, TORTOISE, PEA, GROCER, LARK, CROW, BOW, EASEL, SHEEP, VAULT
**Trial 9**

10 words: RASH, RAPE, TROMBONE, DOE, GRAPH, FLOOR, TRASH, PLIERS, TABLE, FANG
15 words: BERET, OATMEAL, CHESTNUT, CARD, OFFICE, LINT, PASTE, JITTERBUG, PODIUM, GUTTER, VEAL, CELL, VOLCANO, LICE, COFFIN
20 words: LEVER, SECRETARY, BANKER, SHOT, SQUARE, HAMMER, DESTROYER, TIRE, SPADE, CLAMS, FUEL, GASOLINE, BUCKET, BINOCULARS, SLIME, CARPET, NAIL, LENS, TANK, SAPPHIRE

**Trial 10**

10 words: AMBASSADOR, RIB, FLANNEL, GALLON, PLUM, CELLAR, CAPE, VEST, COLONEL, POCKET
15 words: PEW, PULPIT, DOOR, FENCE, MUD, MAST, BLOOD, FLAG, ROPE, SLEEVE, PAN, BLACKSMITH, BILL, BIB, PAIL
20 words: SPOOL, DUST, PLATTER, FROWN, CHALK, BELT, RAM, NUN, JAW, CLAM, TORNADO, KNIFE, LARD, PUMP, LIEUTENANT, ASPHALT, HATCHET, SPINACH, COAL, RIFLE