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Using Linguistic Analysis to Identify High Performing Teams

Social Domain Issues, C2 Analysis, Cognitive Domain Issues

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Abstract

Effective military teams assess ever-changing situations, generate ideas to improve situations, and make decisions, often in threatening environments. Being able to identify teams that perform these tasks effectively would be beneficial for supervisors, trainers, and even group members. This paper examines the usefulness of linguistic analysis (specifically the Linguistic Inquiry and Word Count, LIWC) in identifying potential high performing teams. In a series of studies, distributed and face-to-face groups performed a number of different tasks. The transcripts of all communications among group members were submitted to the LIWC. Correlations were performed between group task performance and the use of many linguistic categories. Across many studies that included groups that differed in size, cohesion level, communication medium, and group membership, results indicated that linguistic analysis is useful in identifying high performing groups. For example, the more group members expressed negative emotions, talked about social processes, and used the present tense as they communicated with one another, the worse the group performed on several tasks. Implications for command-and-control are discussed.

Using Linguistic Analysis to Identify High Performing Teams

Effective military teams perform a wide variety of tasks in an ever-changing and often threatening environment. Team members join the team, often involuntarily, at different times with varying perspectives, knowledge, skills, and abilities, and sometimes leave the team without warning or the ability to train new members to take their place. Knowing which teams are likely to perform well and which are likely to fail would be valuable to military leaders.

In a series of studies reported in this paper, we explore the usefulness of one technological tool, the Linguistic Inquiry Word Count (LIWC; Pennebaker, Francis, & Booth, 2001), in identifying productive groups. The LIWC analyzes text on a word-by-word basis, categorizes each word using 72 linguistic dimensions (e.g., pronoun, present tense, cognitive process), and determines the relative frequency of each linguistic dimension. The words the LIWC categorize are function words, particles, or "junk" words; they are not meaning laden content words, but rather the words we use to hold the content together. Chung and Pennebaker (in press) report, "Whereas the average native English speaker has an impressive vocabulary of well over 100,000 words, fewer than 400 are function words (Baayen, Piepenbrock, & Bulikers, 1995). This deceptively trivial percentage (less than .04%) of our vocabulary accounts for over half of the words we use in daily speech (Rochon, Saffran, Berndt, & Schwartz, 2000) (p. 6)."

Using the LIWC, Pennebaker and his colleagues have found linguistic analysis to predict personality. For example, Pennebaker and King (1999) found that the more people used first person singular pronouns, the higher they scored in neuroticism and the lower they scored in openness. Avoidance of tentative words and the use of social and positive emotion words were characteristics of extroverts. LIWC has been found to predict deception. For example, Newman, Pennebaker, Berry, and Richards (2003) report that deceptive communications, compared to honest communications, contain less cognitively complex language (e.g., fewer exclusive words; perhaps due to the cognitive load of lying) and fewer first person singular pronouns (perhaps to allow people to distance themselves from the lie).

In addition, linguistic analysis is related to psychological and physical health. Rude, Gortner, and Pennebaker (2004) report that the use of first person singular pronouns is related to depression; Pennebaker, Groom, Loew, and Dabbs (2004) report the use of non-I pronouns is related to testosterone level.

Pennebaker, Mehl, and Niederhoffer (2003) suggest that examining the linguistic style of people in social interactions can be useful in understanding relationships. How people communicate with one another, independent of the content of what they are saying, offers us clues into their relationship. Using an example from Chung and Pennebaker (in press), we offer this illustration: Although the same content is implied in these sentences below, the function words the speaker chose to use in expressing the content differ greatly:

"I'd have to say that I like ice cream."

"The experience of eating a scoop of ice cream is certainly quite satisfactory."

"Yummy. Good stuff."

Examining these statements, we get clues about the relationship between the speaker and listener. One particularly useful function word category is first person singular pronouns. Chung and Pennebaker (in press) report that among dyads, the lower status, more subordinate, dyad member uses significantly more first person singular pronouns than the higher status, more dominant dyad member.

We have extended Pennebaker's work to determine if an examination of the function words group members use when communicating with one another as they perform a task can be useful in predicting group performance. In this paper, we report the correlations between word use and group performance across many studies.

Before examining the relationship between word use and group performance, one needs to acknowledge the many ways in which groups differ. It is likely that many group characteristics affect linguistic style and group performance, thereby affecting the relationship between word use and group performance. For example, groups may differ in size. Much research suggests that group size affects interaction style. For example, Bales and his colleagues consistently report that people who talk more get talked to more and that the person in the group who talks the most talks to the entire group more than he or she talks to any one individual. On average, this person begins about 40 to 45% of the communications among group members. The person who talks the next most often initiates only about 23% of the communications, the next one only 17 % and so on. As group size increases, the difference in communication between the person who talks the most and other group members becomes even more severe (Bales, 1953; Borgatta & Bales, 1953; Stephan & Mishler, 1952; Tsai, 1977). Thus, the larger the group becomes, the less evenly distributed the amount of talking is among group members. The linguistic styles predictive of performance among smaller groups may differ than those that predict performance for larger groups.

Similarly, much research suggests that group size affects group performance. For example, larger groups tend to have more conflict, are less cooperative, and have members who conform less to group norms (Erffmeyer, 1984; O'Dell, 1968; Wagner, 1995). The more group members performing a brainstorming task, the fewer ideas per minute per member are generated (Bouchard, Drauden, & Barsaloux, 1974; Bouchard & Hare, 1970; Hackman & Vidmar, 1970; Renzulli, Owen, & Callahan, 1974).

In the studies reported in this paper, most groups were comprised of either three or four members; some studies used dyads (i.e., two member groups). Future research will need to be performed to determine the extent to which our results will generalize to larger group sizes.

Another characteristic of groups is the extent to which members are stratified or hierarchical. Chung and Pennebaker (in press) have found the use of first person singular pronouns (e.g., *I, me, my*) is related to subordinate status and relatively diminished power. Therefore, in groups in which members do not have equal status, we would expect greater use of the first person singular pronouns than in less hierarchical groups.

In every study reported in this paper, the groups were not hierarchical. All group members were given roles of equal status. The extent to which our results generalize to more stratified groups remains to be explored.

Groups differ in their level of cohesiveness. One would hypothesize that cohesive groups may use a different linguistic style when interacting with one another than less cohesive groups. In a meta-analysis examining the relationship between cohesion and performance, Mullen and Copper (1994) concluded that only when cohesion was defined as task commitment was it significantly correlated with performance. Cohesion, as measured by attraction among group members or as measured by group pride, were not related to group performance.

In all but one of the studies reported in this paper, groups were comprised of student participants who did not necessarily know one another. The groups were not cohesive in task commitment, attraction to group members, or in group pride. In one of the studies, the participants worked together either at a local Walmart or at City National Bank. Some of these groups were probably more cohesive than the groups in the other studies.

Another group characteristic that is important in affecting linguistic style and performance is the communication medium (Barkhi, 2005; Becker-Beck, Wintermantel, & Borg, 2005; Kerr & Murthy, 2004; Pissarra & Jesuino, 2005). Electronic meeting systems have been purported to aid U.S. military teams by providing flexible, instant information exchange and efficient activity coordination across geographical boundaries (Chidambaram & Igbaria, 1996). Whether face-to-face groups perform better (Becker-Beck, Wintermantel, & Borg, 2005) or worse (Valachic, Dennis, & Connolly, 1994) than computer-mediated teams,

or whether it interacts with task type (Kerr & Murthy, 2004), it is clear that computer mediated communication affects the manner in which group members communicate. For example, Siegel, Dubrovsky, Kiesler, and McGuire (1986) found that computer-mediated group members were more likely to swear and insult one another than face-to-face group members. In addition, people type messages differently than they say them. Therefore, we would expect communication medium to affect the use of function words and to mediate the relationship between linguistic style and group performance.

The majority of the groups in the studies reported in this paper performed their tasks face-to-face. However, in several of the studies, the groups were distributed. Group members typed their responses into a computer and viewed their group members' responses through a Discussion Board or through GroupShareware.

Groups differ in other significant ways also, for example, the homogeneity of its members, the degree of participation expected, permitted, or demanded of members, the ease of access to membership in the group and ease with which member can leave or be expelled from the group, the degree of stability of the group over time and the continuity of its members over time, the extent to which group members relate to one another intimately vs formally, the degree to which the group is subdivided into smaller groups or cliques, and the extent to which such cliques are in conflict with one another (McGrath, 1984).

In all of the studies reported in this paper, the interactions were informal; the group was created at the beginning of the study and group membership was terminated at the end of the study (usually within two hours). Membership to the group was free, and there was no avenue for group members to expel other group members. The extent to which our results will generalize to other types of groups remains to be explored.

One of the most important group characteristics that affect group communication and group performance is the type of task. There are several task taxonomies that exist (e.g., Steiner, 1972). McGrath's Circumplex (1984) was used to organize our research (see Figure 1). McGrath (1984) identified eight task types that were created from four quadrants representing performance processes: Generate, Choose, Negotiate, and Perform Overt Physical Behaviors. Tasks that border one another in the circumplex are more similar than tasks further away on the circumplex.

The Generate Quadrant is split into Task Type 1: Generate Plans, and Task Type 2: Generate Ideas. The tasks in this quadrant require the group to be creative. Answers are not right or wrong. Usually, the number of ideas or plans generated and the quality of the plans or ideas determine the success of the group. We examined the usefulness of the LIWC in predicting group performance on Task Type 2. In ten studies, participants brainstormed in groups and the words they used as they communicated to one another were correlated with the number of ideas the groups generated.

The Choose Quadrant is made up of Task Type 3: Intellective, and Task Type 4: Decision-Making. Intellective tasks have a correct answer that is demonstrable. Solutions may be "Eureka"-type, in which the correct answer is not only demonstrably correct but also intuitively compelling, Fact-type, in which the correct answer has no intuitive appeal although it can be demonstrated, or Expert-type, in which the solution is based on the consensus of experts. One example of such a task is the Desert Survival Task. Group members are to imagine they are stranded on an island due to an airplane accident. They are to decide which items from a list are most valuable for their survival. Another example of a Type 3 Task is the Hidden Profile task often used by Stasser (Stasser, 1992; Stasser, Taylor, & Hanna, 1989; Stasser & Titus, 1985; 2003; Wittenbaum & Stasser, 1996; Wittenbaum, Hollingshead, & Botero, 2004). In this task, group members are to select the best candidate for student government. Group members are given some overlapping information and some unique pieces of information concerning the candidates.

The Decision-Making tasks (Task Type 4) do not have a true, correct answer. Rather, groups are to select the preferred alternative based on peer consensus. One example of such a task is often used to demonstrate group polarization. Group members are to decide the minimal risk acceptable for various alternatives. For example, participants indicate the minimal risk acceptable for the president of an American corporation which is about to expand to build a new plant in the United States where returns on the investment would be moderate or to build in a foreign country with an unstable political history where returns on the investment would be very high.

In this paper, we report findings from studies we have performed in which we have examined the relationship between performance and the words group members use when communicating with one another as they perform the Desert Survival Task, a Hidden Profile task, and a Group Polarization task.

The Negotiate Quadrant contains task types in which the groups need to choose among alternatives and there is intra-group conflict. Task Type 5 includes tasks in which groups must resolve conflicts of viewpoints. A Choose Quadrant task performed by a multinational team may become a Task Type 5. Task Type 6 includes tasks in which groups must resolve conflicts of interest. An example of a Type 6 task is a social dilemma, in which each group member must decide whether to optimize group or individual outcomes knowing that if everyone chooses to optimize individual outcomes, the entire group will lose. Another example is the Prisoner's Dilemma. In this task, group members are most highly rewarded if they are the only one taking a competitive approach and most highly punished if they are the only one taking a cooperative approach. However, group members are mildly rewarded for joint cooperative acts and mildly punished for joint competitive acts. The game gets its name from the following situation:

> Two suspects are taken into custody and separated. The District Attorney is certain that they are guilty of a specific crime, but he does not have adequate evidence to convict them at a trial. He points out each prisoner's alternatives to him: to confess to the crime that the police are sure they have committed, or not to confess. If they both do not confess, then the District Attorney states he will book them on some very minor but trumped-up charge such as petty larceny and illegal possession of a weapon for which they would both receive minor punishments; if they both confess they will be prosecuted, but he will recommend less than the most severe sentence; but if one confesses and the other does not, then the confessor will receive lenient treatment for turning state's evidence, whereas the latter will get "the book" thrown at him (Luce & Raiffa, 1957, p. 95).

We report findings from three studies performed in which performance was correlated with the words the group members used when performing a modified Prisoner's Dilemma task.

The Overt Physical Behavior Quadrant contains tasks in which the group members perform manual and psychomotor tasks. With Type 7 Tasks, the group performing the physical behaviors competes with other groups. In Type 8 Tasks, the group strives to meet a standard of excellence. We examined the relationship between performance and the words group members used when communicating with each other as they performed two different Type 8 Tasks. In one task, the groups were to build a house from a deck of cards. Groups were to use as many cards as they could without causing the house to fall down. In the other task, group members were to assemble a radio as quickly as possible.

Visualizing the task types on a circumplex, as McGrath did, is useful in identifying other similarities and differences among the tasks (see Figure 1). The tasks on the right side of the circumplex (Types 1, 8, 7, and 6) are tasks that involve action or behavioral tasks; those on the left (Task Types 2, 3, 4, and 5) are conceptual, intellectual tasks. In addition, tasks on the top of the wheel (Task Types 3, 2, 1, and 8) are cooperative tasks and those on the bottom (Task Types 4, 5, 6, and 7) are conflict tasks.

The purpose of this paper is to examine the relationship between linguistic style and group performance among groups performing various tasks. The ability to predict which groups will perform certain tasks well and which are likely to fail would benefit all group leaders.

Generate Quadrant: Brainstorming

Groups are often asked to brainstorm together to generate ideas. Osborn (1957) was the first to formally present brainstorming as a procedure for idea generation. He instructed group members (a) to generate as many ideas as they can, (b) to say anything and everything that they think of, (c) to integrate ideas that have been presented into better ones, and (d) not to criticize their own or others' ideas. He believed brainstorming groups would generate more and better ideas than individuals working alone. In fact, he predicted that group members following these brainstorming rules would generate twice as many ideas than if the members had worked alone.

Osborn (1957) did find, as did others (Meadow, Parnes, & Reese, 1959; Parnes & Meadow, 1959; Weisskopf-Joelson & Eliseo, 1961), that brainstorming groups produce more ideas than other kinds of groups (e.g., critical groups or non-brainstorming groups). However, studies find that brainstorming groups do not generate as many ideas as the combined output of an equal number of people brainstorming separately (see Mullen, Johnson, & Salas' meta-analysis). Taylor, Berry, and Block (1958), who were the first to make this comparison, referred to the latter group as the nominal group. The former group is referred to as an interactive group.
Although interactive brainstorming groups generate fewer ideas than the combined output of the same number of members working individually, many businesses still encourage employees to brainstorm in groups (cf., Mullen, Johnson, & Salas, 1991). This may be due to the fact that interactive group members *perceive* their performance to be superior to nominal group members (Paulus, Dzindolet, Poletes, & Camacho, 1993). Perhaps this perception is prevalent because there are certain advantages to working in a group that are not present when working alone. For example, group members can listen to others' ideas which may stimulate each group members' thinking. In addition, organizations may value other consequences of group interaction (e.g., support of the organization's memory of solutions, provision of a positive impression to clients, generation of income) more highly than the generation of ideas (cf., Sutton & Hargadon, 1996). Organizations often use facilitators to guide brainstorming groups, which can help interactive group brainstorming performance (Oxley, Dzindolet, & Paulus, 1996).

Various theories have been proposed to account for the performance gap between interactive and nominal groups. Blocking theorists (Diehl & Stroebe, 1987; 1991) hypothesize the inferior group performance is due to the conversational rule that only one member of a group can speak at any given time. While one member of the group shares an idea, the other group members are unable to share their ideas, may be distracted from generating new ideas, may negatively evaluate a generated idea and decide not to share it, and may forget previously generated ideas.

Other researchers hypothesize that group members fear other members will evaluate them negatively. The evaluation apprehension increases arousal and reduces creative responses, especially for difficult or novel tasks (Collaros & Anderson, 1969; Cottrell, 1972).

Social Loafing and Free-Riding have also been used to explain the inferiority of group to nominal brainstorming (Karau & Williams, 1993; Kerr, 1983). Group members can diffuse the responsibility of the task to other group members and are provided the opportunity to rely on the work of others in the group, who may be perceived to be better at performing the task. Therefore, people work less hard in a group than they work when they are alone.

Social Influence theorists (Brown & Paulus, 1996; Camacho & Paulus, 1995; Paulus & Dzindolet, 1993; Paulus, Dzindolet, Poletes, & Camacho, 1993) believe that group members match their rate of performance to others in the group. The initial blocking and evaluation apprehension lead to a low rate of performance which is then perpetuated through social matching.

The interactions from interactive brainstorming groups in ten separate studies[1] were submitted to the LIWC and the word categories used by group members were correlated with the number of ideas the group members generated in order to identify the linguistic pattern of high performing brainstorming groups.

Method

All groups in the ten separate studies were provided with a page that stated Bouchard and Hare's (1970) brainstorming rules. Specifically, they were told:

> We would like you to brainstorm as a group. The brainstorming technique is a form of group interaction, which is used to facilitate the flow of ideas. It is widely used in a large number of U.S. corporations, and is generally used when new, unique, original, and creative ideas are desired. It is not used to solve everyday problems. The procedure is relatively straightforward, and easy to comprehend. The following rules are for brainstorming in groups. We want you to apply these rules as best you can, while working on the problem as a group. What we are interested in is how groups brainstorm. The rules are as follows:
>
> 1. Criticism is ruled out. Adverse judgment of ideas must be withheld. No one should criticize anyone else's ideas. Say everything you think of.
>
> 2. Freewheeling is welcome. The wilder the idea, the better. It is easier to tame down than to think up. Don't be afraid to say anything that comes to mind, the farther out the idea, the better. This will stimulate more and better ideas.
>
> 3. Quantity is wanted. The greater the number of ideas, the more likelihood of winners. Come up with as many as you can.
>
> 4. Combination and improvement are sought. You should try to suggest how ideas of others can be joined or changed into still better ideas. Don't be afraid to combine and improve on them.

The instruction page also included the brainstorming problem and the amount of time the group had to brainstorm.

Although all participants in the ten studies received the same brainstorming instructions, the studies differed in many significant ways: (1) *Group Size.* The size of the groups included dyads, triads, and groups of four members. (2) *Time.* The amount of time the groups were allotted to brainstorm ranged from 5, 10, 20, and 45 minutes. (3) *Group Cohesiveness.* In most of the studies, ad hoc groups were formed. However, in one study, some of the groups were established. (4) *Research Location/Participants.* Several of the studies used Cameron University students; others used students from the University of Texas at Arlington. The group members in these studies were students and most received extra credit in a psychology course or partially fulfilled a research participation requirement in a General Psychology course by participating in the study. One of the studies used employees from Walmart and a local bank. These employees were not given anything for their participation. (5) *Communication Medium.* Most of the groups brainstormed face-to-face. These participants were provided with individual microphones and tape-recorders at the beginning of the session. The entire brainstorming session was recorded. A transcript from each group member was created from the tape and combined with transcripts from

other group members to examine group performance. A few of the studies included groups that brainstormed in a distributed fashion. In these studies, participants typed their responses rather than speaking them out loud. They were able to read the responses written by other group members brainstorming in other rooms immediately (distributed) or upon pressing a button (ShareWare). The procedure for communicating was very similar to communicating in a chat room on-line. (6) *Brainstorming Problem.* Several of the studies used the Thumbs Problem. Participants were told:

> The problem we want you to work on is called the Thumbs problem. We do not think this is likely to happen, but imagine for a moment what would happen if everyone after 2006 had an extra thumb on each hand. This extra thumb will be built just as the present one, but located on the other side of the hand. It faces inward, so that it can press against the finger just as the regular thumb does now. Here is the question: What practical benefits or difficulties will arise when people start having this extra thumb?

Several of the studies asked groups to generate ideas to improve their university (University of Texas at Arlington):

> What do you think could be done to improve the University of Texas at Arlington? Please consider all aspects of the university -- academic resources, social, artistic, and intellectual activities, athletics, physical facilities, library, student-faculty ratios and relationships, opportunities for students, freedoms, limitations, classes, scheduling, etc... These are only examples to get you started. What would you keep the same? What would you change, and how?

In one study, groups brainstormed about their ideal university:

> You are a committee member of a group who will be conducting the planning for opening a university. What would be your recommendations regarding the establishment of this new institution of higher education (i.e., campus groups, facilities, faculty, requirements, campus procedures)?

The Ecology Problem was used in two studies. Specifically, participants were told:

> Many people have made an extensive analysis into the effects of overpopulation, chemical pollution, and air and water pollution. A frequent conclusion is that the next 5 to 10 years are critical because if significant changes in our society are not made by then, it may be too late to save the environment and maybe even future lives. Students are often more aware and more concerned with the environmental crisis than the majority of Americans. Therefore, what as *students* can you do to effectively implement significant changes in the society in order to halt and alter the present trend?

In one study, groups generated ideas to improve the social life of teenagers in their community. Table 1 reports the key characteristics for each of the ten studies.

Results and Discussion

The oral communications were transcribed into Word files; transcripts from the distributed groups and groups using group shareware were saved as Word files. The files were submitted to the LIWC, which determined the groups' use of each of the word categories.

For each study, at least two raters independently determined the number of ideas generated by each group. Inter-rater reliability was assessed with a Pearson r and was greater than .90 in each study. Correlations between the number of ideas the groups generated and the use of the word categories were determined separately for each study.

The correlations for key linguistic categories are presented in Figures 2 through 33. In each figure, the correlations are presented on the y-axis; a star near a bar indicates that the correlation was significant at the alpha = .05 level.

Across most of the studies, the more pronouns group members used when generating ideas, the fewer ideas they generated (see Figure 2). This effect appears to be due to the relationship between the use of first person singular pronouns (i.e., *I, me, my*) and performance (see Figure 3). The use of first person plural pronouns (e.g., *we, our, us*; see Figure 4), second person pronouns (*you, your;* see Figure 5), and third person pronouns (*he, she, they;* see Figure 6) were not consistently related to brainstorming performance.

Why might the use of first person singular pronouns be related to poor brainstorming performance? At least three explanations exist. First, the use of first person singular pronouns is related to a self-focus rather than other-focus. Might this negatively affect brainstorming performance? To examine the effect of other-focus on performance, we examined the relationship between performance and the use of words that reference other people. No significant correlations were found (see Figure 7).

Second, people use first person singular pronouns more when they feel subordinate in a relationship. These feelings of inferiority might also inhibit creativity, thus harming group brainstorming. One way to explore this hypothesis is to focus on the use of "confidence" words. People who feel inferior in the group are probably likely to use more tentative words and fewer words indicating certainty (e.g., *clearly, confidently*) than those who feel more superior. However, use of these words was not found to be related to brainstorming performance (see Figures 8 and 9).

Finally, the use of first person singular pronouns would be higher in groups in which members are asked to defend their responses. To examine this idea, we focused on the use of negate words (e.g., *no, never, not*) and assent words (e.g., *yes, O.K.*). Figure 10 illustrates a trend that poor relations among group members may be related to poor brainstorming performance. The use of assent words was not consistently related to brainstorming performance (see Figure 11).

Future research will need to be performed to determine the cause of the relationship between the use of first person singular pronouns and inhibited brainstorming performance. However, one thing is clear: If you notice brainstorming group members using first person singular pronouns, it is likely the group will not be very productive. Using the LIWC to diagnose groups should prove to be useful to military leaders.

The Evaluation Apprehension explanation for the gap between interactive and nominal group performance hypothesizes that group members experience more anxiety than individuals. Groups with less evaluation apprehension should perform better than those with more apprehension. The anxiety experienced by the group members should lead to less cognitively complex language (Yerkes-Dodson Law, 1908; Drive Theory of Social Facilitation, Zajonc, 1965). Similarly, the Social Loafing and Free-Riding explanations would lead one to predict a relationship between performance and the complexity of the language used by group members. Group members who are not trying very hard are unlikely to use cognitively complex language.

The use of words with six or more letters and causal words are indicators of cognitive complexity. We would expect these words to be positively correlated with brainstorming performance. In only two of the ten studies were words with six or more letters related to brainstorming performance (see Figure 12) and the use of causal words was found to be related to reduced, not enhanced, brainstorming performance (see Figure 13).

Words of exclusivity (e.g., *but, except, without*), and inclusiveness (e.g., *together, with, also*), are indicators of less cognitively complex language (Newman et al., 2003). Examination of Figure 14 reveals that the use of exclusive words is negatively related to brainstorming performance. Although the relationship between group brainstorming performance and the use of inclusive words was not consistent across all ten studies (see Figure 15), some support for the hypothesis was found.

Indicators of concrete rather than abstract thought include the use of articles (e.g., *a, the*), prepositions (e.g., *for, to*), and numbers. Since concrete thought is less cognitively complex than abstract thought, we explored the relationship between the use of these words with group brainstorming performance. An examination of Figures 16, 17, and 18 reveal these words are not indicators of brainstorming performance.

Therefore, consistent with the evaluation apprehension, social loafing, and free riding hypotheses, some evidence exists that brainstorming groups whose members use more cognitively complex language (more words with six or more letters, fewer exclusive words, and fewer inclusive words) generate more ideas than brainstorming groups whose members use less cognitively complex language. However, the use of concrete language was not related to brainstorming performance.

According to the Production Blocking explanation, groups do not generate as many ideas as individuals because group members cannot talk whenever they wish. Specifically how this inhibits idea generation has yet to be determined. Diehl and Stroebe (1987; 1991) did conclude that it is *not* due to the fact that group members have less time to generate and share ideas. Having to wait one's turn may be frustrating at times. Did this "leak" into the group members' communications? We examined the use of words expressing negative and positive emotions with performance. An examination of Figures 19 to 25 reveals little support, although in two studies the use of negative emotion words (*hate, worthless, ugly*) was related to poor performance.

Social Influence theorists suggest that evaluation apprehension, social loafing and free-riding, and production blocking inhibit brainstorming performance initially. However, they believe that the low level of brainstorming is maintained because group members match their level of performance to that of the other group members' performances. The use of discrepancy words (e.g., *should, could*), and other words indicating social processes may be predictive of brainstorming performance. Although the use of discrepancy words (see Figure 26), and social mechanisms (see Figure 27) was not consistently related to brainstorming performance, there was a trend in several studies that the more group members used communication words (e.g., *talk, ask, chat*), the fewer ideas they generated (see Figure 28).

Do the high performing brainstorming groups think differently, and, if so does this difference "leak" into their communication with one another? In two of the studies, talking about cognitive processes (e.g., *acknowledge, inform*) was related to poor brainstorming performance (see Figure 29). Although we cannot be sure that this finding is not due to procedural differences between high and low performing groups, the fact that the use of insight words (e.g., *think, know, believe;* see Figure 30) is negatively related to brainstorming performance suggests it is due to cognitive differences.

Finally, we examined the relationship between the tense of the communications shared among group members and their performance. Although the results were inconsistent (see Figures 31 to 33), in three of the studies, the more group members used the present tense, the fewer ideas they generated. It is not clear whether tense will be useful in identifying high performing groups at this time.

Conclusion for the Generate Quadrant Tasks

In summary, the results from these ten studies indicate that linguistic analysis, specifically the LIWC, is useful in identifying high performing brainstorming groups. In at least four of the ten studies, the more group members avoided first person singular pronouns, negate words, exclusive words, insight words, and the present tense, the more ideas the group generated. In addition, in at least two of the ten studies, the more group members avoided the use of inclusive words, communication words, words indicating cognitive processes, causal words, and words expressing negative emotions, the more ideas the groups tended to generate. This pattern appeared across studies that included groups of differing size brainstorming on different problems using varying communication

mediums at different locations. A meta-analysis should be performed to determine the overall effect size of these relationships.

Quadrant: Choose Tasks: Intellective and Decision-Making Tasks

Oftentimes after brainstorming, groups are asked to choose which of the generated ideas is "best." Can the LIWC predict which groups are likely to perform well on the Choose Quadrant tasks? We examined the relationship between word use and group performance for three completely different types of Choose Tasks: the Desert Survival task, the Hidden Profile task, and a Group Polarization task. Will the use of first person singular pronouns, cognitive complex language, and tense predict performance on intellective and decision-making tasks as it did for brainstorming tasks?

Desert Survival Task Method

Thirty-six Cameron University students formed six dyads and eight triads. Students were asked to rank order 15 items in terms of their utility for desert survival in 15 minutes. Specifically, participants were told:

> As a group, please consider you are in the following situation: It is approximately 10:00 in the morning on a mid-August day and you have just crash-landed in the Sonora Desert in the southwestern United States. The light twin-engine plane, containing the bodies of the pilot and co-pilot, has completed burned. Only the airframe remains. The rest of you are uninjured.
>
> The pilot was unable to notify anyone of your position before the crash. However, he had indicated before the impact that you were 70 miles south-southwest from a mining camp, which is the nearest known habitation, and approximately 65 miles off the course that was filed in your VFR Flight Plan.
>
> The immediate area is quite flat and, except for occasional barrel and saguaro cacti, appears to be rather barren. The last weather report indicated that the temperature would reach 110 degrees F today, which means that the temperature at ground level will be 130 degrees. You are dressed in lightweight clothing—short-sleeved shirts, pants, socks, and street shoes. Everyone has a handkerchief. Collectively, you have in your pockets $2.38 in change, $85.00 in bills, a package of cigarettes, and a ball-point pen.
>
> Before the plane caught fire, your group was able to salvage the 15 items listed below. Your task is to rank the items according to their importance to your survival, starting with a "1" for the most important to "15" for the least important.

Students earned Research Participation Credit for their participation. This was used to fulfill a requirement for a General Psychology course or to earn extra-credit in higher level psychology courses.

Each group member was given his or her own microphone and tape-recorder. All communication among group members was recorded.

Desert Survival Task: Results and Conclusion

The tapes from members of the same group were transcribed and combined into one file and submitted to the LIWC. Group performance was determined by the number of correct items chosen as determined by survival experts. Correlations between the use of the LIWC categories and group performance were calculated separately for dyads and triads. Due to the small sample size and lack of power, none of the correlations were significant at the .05 level. However, some of the correlations were of large magnitudes (less than -.80 and more than .80). These trends will be discussed.

Among dyads, there was a trend for pronoun use to be negatively related to performance (see Figure 34). This appears to be driven by first person singular pronouns and second person pronouns. Although not reaching standard levels of significance, the more dyads used *I*, *me*, *my*, *you*, and *your*, the fewer correctly chosen items they selected from the list. For groups of three, there was a trend for the use of third person pronouns to be positively correlated with performance. Although not reaching standard levels of significance, the more triads used *he*, *she*, and *they*, the more items they correctly chose from the list (see Figure 34).

Did the higher performing groups use more cognitively complex language when they communicated with one another? Although not reaching standard levels of significance, the more dyads used negations, indicating less cognitively complex language, the worse the dyads performed (see Figure 35). No such relationship existed among groups of size three. Similarly, there was a trend among dyads for the use of complex words (e.g., words with six or more letters) to be positively correlated with performance (see Figure 35). In addition, the use of prepositions was related to poor performance among both dyads and triads (see Figure 36). Inconsistent with the above findings suggesting that cognitive complexity of communications among members was positively correlated with performance, the use of exclusive words and numbers (both indicators of a less cognitively complex language style) by dyads was positively related to performance (see Figures 35 and 36).

Do high performing group members experience different emotions as they perform intellective tasks than poor performing group members? If so, do their emotions "leak" into their communication with one another? An examination of Figure 37 reveals a trend that suggests that, at least among triads, the more members express emotions—specifically, negative emotions—the better the groups' performance. Among dyads, the trend is weak and in the opposite direction.

Examining Figure 38, one can see that talking about cognitive mechanisms and using insight words was not predictive of group performance. However, there is a weak trend that the use of discrepancy words is related to group performance. Although not reaching standard levels of significance, among dyads, discrepancy words were related to poor performance. However, among triads, the use of discrepancy words was related to better group performances.

There was a trend among dyads such that talking about social processes and using communication words when discussing which of the 15 items were most necessary for survival was related to poor performance (see Figure 38).

Although not reaching standard levels of significance, the more groups used the past tense as they communicated to one another about the items to help them survive in the desert, the better they performed. Among dyads, the use of the present tense was related to poor group performance (see Figure 39).

Although the sample sizes were very low in this study, high performing dyads avoided prepositions and used numbers. In addition, there was a trend for high performing dyads to avoid pronouns, negations, discrepancy words, communication words, and the present tense and to use the past tense, exclusive words, and words with six or more letters when communicating with one another about which items would best help people to survive in the desert. Among groups of three, the use of prepositions was related to poor performance. There was a trend for high performing groups to use third person pronouns, words expressing negative emotions, and speak in the past tense.

Would this pattern of results generalize to another Type 3 Task? Dzindolet, Stover, and Pierce (2005) asked dyads and groups of four to perform a Hidden Profile Task. This specific task does not use arrival at a correct

answer as the measure of group performance. Rather, the amount of time groups spend discussing certain pieces of information is examined.

One reason why group decisions are assumed to be superior to individual decisions is that group members can pool their individual resources to make a decision that takes into account much more information and many more perspectives than any one individual can. However, Stasser and Titus (1985; 2003) have found that group members often fall into the trap of talking about information that all the members have in common rather than focusing on the individual, unique pieces of information that would help lead to improved decision making (Stasser, 1992; Stasser, Taylor, & Hanna, 1989; Wittenbaum & Stasser, 1996).

Although certain procedural interventions created to prevent groups from falling into this trap have showed some promise (see Kerr & Tindale, 2004 for a summary), the ability to predict groups that are more (or less) likely to fall into this trap would be useful to team leaders. Dzindolet, Stover, and Pierce (2005) examined the usefulness of the LIWC in identifying groups that spend much of their decision-making discussion time focused on shared and unique information.

Hidden Profile Task Method[2]

One hundred and four Cameron University students performed a decision-making task in a face-to-face group of four (15 groups; N=60) or as a dyad (22 dyads; N=44). The status of the group members was not manipulated in any way. Participants were told that they should decide which of three candidates (Student A, Student B, or Student C) would be the best Student Government President. They were told that they would each be given a list of characteristics about the candidates. They were instructed:

> As is often the case with groups that are asked to make decisions, the information you are each given may differ. You will need to share your information with the group in order for the group to make the best decision. After 10 minutes has passed, the experimenter will return to this room and ask the group to indicate which candidate you, as a group, choose to be Student Government President.

Group members were provided with four adjectives to describe each of the three candidates. All group members were informed that Candidate B was friendly, organized, deceptive, and obnoxious. Similarly, all group members were informed that Candidate C was calm, communicated well, untruthful, and overzealous.

However, two unique characteristics that described Candidate A were distributed to each group member. All group members were informed that Candidate A was disrespectful and not punctual. However, only one group member was informed that Candidate A was intelligent and charismatic. Another was informed Candidate A was motivated and took initiative. Among four member groups, only one member was informed Candidate A was hardworking and had much experience in the Student Government Association; another was informed Candidate A was honest and sang well.

Students either earned extra-credit in a class offered in the Department of Psychology and Human Ecology or earned research participation credits which fulfilled a requirement for General Psychology for their participation.

Hidden Profile Task: Results and Conclusion[2]

The ten-minute discussions were transcribed into Word files and were entered into the LIWC. Next, the number of seconds each group spent information gathering, discussing shared information, discussing unshared information, making the decision, and off-task talk was determined for each group. A t-test revealed that the 23 groups that arrived at the correct answer (Candidate A) spent significantly more time discussing the unique pieces of information (M = 34.27) than those that arrived at an incorrect decision (Candidate B or C; M = 3.13),

$t(31) = 2.66$, $p < .02$. Therefore, time spent discussing unique pieces of information is an indicator of an effective decision-making strategy on this intellective task. Time spent discussing shared or common information is an indicator of a poor group strategy.

Correlations between the relative frequency of each of the LIWC word categories used during the entire ten minute discussion and the time spent on each of the group functions were computed. Correlations between LIWC categories and time spent on unshared and shared information performed separately for the dyads and the four-member groups revealed distinct linguistic markers.

Among dyads, the use of second person pronouns was related to the poor strategy of spending time discussing information common to all group members (see Figure 40). Among groups of four, the more first person singular pronouns and second person pronouns were used by members, the more time the group spent using the efficient strategy of discussing unique pieces of information (see Figure 41).

Was the use of cognitively complex language related to the strategies? Among dyads, the use of causal words, a level of cognitive complexity, was positively correlated to both the time spent on discussing shared and common information (see Figures 42 and 43). The use of exclusive words and prepositions, thought to be indicators of less cognitively complex and more concrete language (Newman et al., 2003), were positively correlated to the time spent on the inefficient strategy of discussing common information (see Figures 42 and 44). Among groups of four, the use of causal words was related to the efficient strategy of focusing on unique information (see Figure 43).

Among groups of four, the use of words that express emotions—especially negative emotions—was positively correlated to time discussing information the group members already had in common, an inefficient decision-making strategy. None of the indices of emotion were significantly related to time spent discussing shared or unique information among dyads (see Figures 46 and 47).

Using words that indicate cognitive and social processes was related to the time groups spent discussing common information, although the only correlation to reach standard levels of statistical significance was for the use of social words by dyads (see Figure 48). A trend existed for groups that used social and communication words to spend more time discussing unique pieces of information (see Figure 49).

Among dyads, the more members used the present and future tenses, the more time they spent in the inefficient strategy of discussing information they had in common. Among groups of four, the less time group members used the past tense and the more they used the present tense, the more time they spent caught in this trap (see Figure 50). Tense was not related to time spent discussing unique pieces of information (see Figure 51).

In summary, the more members of groups of four used the efficient strategy of discussing unique pieces of information, the more likely they were to use first person singular pronouns, second person pronouns, and causal words. Among dyads, only the use of causal words was an indicator of this efficient strategy. The more members of groups of four used the inefficient strategy of discussing information members already have in common, the more the group members expressed their emotions, especially negative emotions, and the more they used the present tense and avoided the past tense. Among dyads, the more members used second person pronouns, causal and exclusive words, prepositions, social words, and the present and future tenses, the more time the dyad spent discussing information the two members had in common.

Summary of Intellective Tasks

Examining the pattern of results for the Desert Survival Task and the Hidden Profile task, one notices little overlap. The only word category that was significantly correlated with performance for both tasks and across more than one group size was prepositions. The use of prepositions was related to poor dyad performance on the Desert Survival Task and to the inefficient strategy of discussing shared information among dyads performing the Hidden Profile task. However, no other word category identified high performing dyads and groups for both tasks. This suggests that the relationship between word use and performance may differ for each task type. Future research will need to determine if this is true.

The next study to be examined used a Type 4 Choose Task, one in which a true correct answer does not exist. Rather, consensus among peers is used. The paradigm used is common among researchers studying group polarization.

Group Polarization Method

One hundred and fifty Cameron University students were given a list of scenarios (see Table 2). For each scenario, participants were to determine the level of risk they would be comfortable taking. Each participant made his or her decisions alone and recorded them on a page.

Next, participants were put into face-to-face groups of two (15 dyads; n = 30) or four members (15 groups; n = 60) or in a distributed group of four (15 groups; n = 60) and asked to discuss their decisions with their group members for thirty minutes. A clip-on microphone was attached to each face-to-face group member; each microphone was attached to its own tape-recorder. Distributed group members were located in different rooms and communicated via a computer. All of the computers had access to the internet and a Blackboard program. The group members had real time access to each other. They were able to type their responses and see other group members' responses simultaneously.

At the end of the thirty minutes, each group was asked to report their group decisions onto a page similar to the one they had completed as individuals earlier. Finally, each group member was asked to complete the assignment once more as an individual. Participants were assured that other group members would not see their answers. Performance in this paradigm is an index of similarity of the final individual responses with the group's responses. It is a measure of the extent to which the group truly reached consensus.

Group Polarization Task: Results and Conclusion

Pronouns use, cognitive complexity, and the expression of emotions were not significantly related to true consensus among group members in any of the three conditions (see Figures 52 to 56). However, among face-to-face dyads, the use of social words and the use of communication words were negatively correlated with consensus (see Figure 57); the use of the future tense was positively correlated with consensus (see Figure 58). No other significant correlations were revealed.

Summary for Quadrant Choose Tasks

We examined the correlation between performance and word use among groups performing three different tasks. For each task, group size affected the performance-word use relationships, and there was little consistency across the three tasks. The more dyads avoided using social words, the better they performed on all three tasks. Three other word categories predicted performance in more than one task. Specifically, the more dyads performing the Desert Survival Task and the Group Polarization Task avoided communication words, the better they did. The more dyads and groups performing the Desert Survival Task and dyads performing the Hidden Profile Task avoided prepositions, often thought to indicate concrete rather than abstract thinking, the

better the groups did. Finally, the more dyads performing the Desert Survival Task and groups of four performing the Hidden Profile Task avoided words indicating emotion, the better the groups performed.

Future research should attempt to replicate these findings with other groups. In addition, different Type 3 and Type 4 tasks should be explored. Within each task and task type, researchers should determine if the same pattern of results is found with groups of different sizes, groups whose members vary in status, and with distributed and less homogeneous groups.

Quadrant Negotiate Tasks

As discussed earlier in the paper, in prisoner dilemma tasks, group members are most greatly rewarded for being the sole competitor in a group and most greatly punished for being the sole cooperator. However, cooperative responses by all group members lead to more favorable rewards than competitive responses made by all group members. Research with prisoner dilemma tasks indicates that communication among group members increases the likelihood the group members will act in a cooperative way. Pruitt (1998) outlines six explanations for this effect: (1) discussion allows groups to discuss and agree upon cooperative norms, (2) discussion gives group members the opportunity to put pressure on other members to follow the created norms, (3) during discussion, group members often publicly commit to cooperating, which increases the likelihood that they follow this behavior, (4) discussion may help group members to form a common identity, (5) discussions increase the likelihood that group members will expect others to act in a cooperative manner increasing the likelihood that they will, and (6) discussion encourages long-term thinking which tends to favor cooperative responses. Will the LIWC be able to identify which groups have members that are likely to cooperate? An adapted prisoner dilemma task was used (Kiesler, Sproull, & Waters, 1996) to examine this question.

Method

Seventy-nine Cameron University students were placed into one of three conditions. Participants formed distributed dyads (14 dyads; n = 28), face-to-face groups of three (8 groups; n = 24), and distributed groups of three (9 groups; n = 27) and were informed that the experiment was a study of investment choices in different situations and that they would be making investment choices with investment partners. The subjects were then directed to look at the pay-off matrix (see Table 3). In each trial, participants had to choose from either project blue or project green individually. Groups were given five minutes to talk with one another before making each decision. How much money individuals would earn depended on what project they and their group members chose as indicated by the matrix. Five trials took place. Group performance was determined by the average number of project green choices, the cooperative choice, made per member.

Results and Conclusion

The only significant correlation was between the use of discrepancy words and cooperative choices among distributed groups of three. The more group members used these words which often indicate standards (e.g., *should, would, could*), the more cooperative the group members were (see Figures 59 through 65). None of the other correlations reached standard levels of significance. However, there was a trend that the more dyads avoided second person pronouns, the more cooperative the dyad members were. In addition, the more face-to-face triads expressed positive emotions, negative emotions, and used anger and exclusive words, the more cooperative they were with one another. This somewhat counter-intuitive finding warrants further investigation. In addition, although not reaching standard levels of significance, the more distributed dyads and the less face-to-face triads used the future tense, the more cooperative they were with their group members.

Quadrant: Overt Physical Behavior

Two different Type 8 Tasks were used to explore the relationship between group performance and word use. In one study, we asked participants to make a house from a deck of cards; in the other, we asked groups to put together a radio.

House of Cards Method

Twenty groups of three persons participated in this study. Ten groups were employees of Wal-Mart in Lawton, Oklahoma; ten groups were employees from City National Bank, Lawton, Oklahoma. Some of the groups were newly-formed; the members had not worked together. Other groups included employees who did regularly work together. The data from both types of groups were combined in this report.

Groups were asked to create a house from an ordinary deck of playing cards in ten minutes. Participants were told if they finished one structure before the time limit, they could begin another structure. Group performance was determined by the number of cards used.

While performing the task, one tape-recorder was placed on the table. Unlike the other studies reported in this paper, each group member did not have his or her own tape-recorder. Participants knew they were being audio-taped as they performed the task.

House of Cards: Results and Discussion

None of the correlations between performance and pronoun use, linguistic indicators of cognitive complexity, cognitive, or social processes, expressions of emotion, or tense were significant (see Figures 66 through 71). Is the LIWC unable to identify group performance for Task Type 8? To answer this question, we performed another study in which groups of two or three members performed a Type 8 Task, specifically, groups assembled a radio.

Radio Assembly Method

Thirty-nine Cameron University students formed six dyads (n=12) and nine triads (n=27) and were given 15 minutes to assemble a radio (Liang, Moreland & Argote, 1995). Specifically, participants were told:

> As a group, we would like you to assemble the AM portion of a radio. Specifically, your group will be given a Radio Kit from Radio Shack (Item/Model #2800179). The kit includes a circuit board and dozens of mechanical and electronic components (e.g., resistors, transistors, capacitors). The circuit board contains pre-punched holes with special symbols indicating where different components should be placed. To assemble the AM portion of the radio, you will need to insert dozens of components into different places on the circuit board and then connect each component to the others in the proper manner. You will not be given any special tools to perform the task. However, you will be given the instructions included in the Radio Kit. You will have 15 minutes to assemble the radio as a group. Please do not begin until the experimenter tells you to do so.

The dependent variable was the time it took for the group to assemble the radio. Each participant wore a clip-on microphone, which was attached to a tape-recorder. Transcripts were created and transcripts from members of the same group were combined.

Radio Assembly: Results and Conclusions

Due to the small sample size, power was low. Only two correlations between word use and performance were significantly different from zero (see Figures 72 to 78). The more triads used words of six or more letters, indicating cognitively complex thought, the faster they completed the radio assembly task (see Figure 73). Among dyads, the more they used prepositions, an indicator of more concrete and less cognitively complex language, the longer it took the dyad to assemble the radio (see Figure 74).

Although not reaching standard levels of significance, other correlations indicated that use of certain word categories accounted for nearly 40% of the variance in group performance. Such findings are discussed below but should be viewed with caution.

Although not reaching standard levels of significance, pronoun use among dyads, but not triads, was positively related to performance. The more dyads used first person singular pronouns and second person pronouns, the more quickly they completed the assembling of the radio. Among dyads, the use of negate words, indicating less cognitively complex thought, words expressing positive feelings, words indicative of cognitive and social processes, and the present tense were related to quick assembling of the radio. However, use of articles and anger words was related to slower performances. Among groups of three, causal words, discrepancy words, exclusive words, words indicating cognitive mechanisms, and the use of the present and future tenses were related to slower performances. In addition, use of prepositions and numbers among triads were related to better, quicker performances.

General Conclusions

Table 4 presents a summary of the significant and marginally significant correlations between group performance among all 23 studies and each of the key linguistic categories. Examination of the table suggests that although the LIWC is useful in predicting group performance, the relationships between word use and group performance change with task type, problem, group size, and communication medium. A few overall patterns do appear. First, the cognitive complexity of the language group members use as they communicate with one another is related to group performance. Specifically, in several studies, the more groups used words with six or more letters and avoided prepositions, both indicators of more cognitively complex language, the better the groups performed. Second, expressing negative emotions is related to poor performance. Third, the more group members talked about social processes, the worse they performed. Finally, in seven of the studies, the more groups used the present tense as they communicated with one another, the worse they performed on their tasks.

However, none of these linguistic markers was successful in predicting performance in a majority of studies. For this reason, these specific patterns should be received with caution. The main contribution of this line of research is not in its ability to identify specific linguistic markers that will predict performance for a wide variety of tasks and group types. Rather, this line of research demonstrates the usefulness of the LIWC in identifying high performing groups for a particular type of group communicating in a particular fashion performing a particular task. In only one of the twenty-three studies was the LIWC incapable of identifying at least one linguistic marker for group performance.

The results from these studies suggest that team leaders could be able to identify high performing teams with a little research of their own. The team leader should have many groups of the same size, communicating with the same medium, perform the same task. The group size, communication medium, and task type should be identical to the one in which the team leader is interested. After collecting data from many groups, the transcripts from the communications among group members should be submitted to the LIWC. Correlations can be calculated between each of the linguistic categories and an objective measure of group performance. In a

relatively short period of time, the team leader could have a way of identifying groups which are likely to perform well and groups which are likely to have problems. This could be used to assess whether a new group or team has spent enough time training or whether an old group or team is tired, burned out, or no longer functioning well.

The analysis of the data collected and reported in this paper is limited in many ways. The groups were small (four people at the most) and were mostly comprised of people who did not know one another and knew they would never have to work together again in the future. There were never any real positive consequences for performing well or negative consequences for performing poorly. The tasks they performed never took more than a few hours to complete. Future research should examine the relationship between the use of function words and group performance among "real world" groups and teams, especially among long-term groups and teams. Multinational teams should be examined to determine the effect of group homogeneity on the word use-performance relationship. In addition, the linguistic markers for performance should be examined as groups experience various levels of stress. The linguistic indicators of performance may be different in a threatening environment than in a safe one. Focusing on group performance, we have ignored examining the usefulness of the LIWC in predicting group functions. The extent to which the function words group members use when talking with one another relate to trust or conflict among group members or suggest hidden agendas has yet to be explored.

Although there are many limitations to these studies, the findings from this report suggest that the Linguistic Inquiry Word Count, a simple computer program that calculates the relative frequency of "junk" words people use when talking with one another, can aid in predicting group performance.

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Footnotes

[1] The performance data (i.e., the number of ideas generated) for nearly every study has been reported in other paper presentations or publications. The table below includes this reference information.

Study	Reference
1	Batka, J., Beadles, E., & Dzindolet, M. (2003, November). *The relationship between language use and brainstorming performance among distributed and face-to-face groups*. Paper presented at the 92th annual technical meeting of the Oklahoma Academy of Science, Chickasha, OK.
2	Batka, J., Beadles, E., & Dzindolet, M. (2003, November). *The relationship between language use and brainstorming performance among distributed and face-to-face groups*. Paper presented at the 92th annual technical meeting of the Oklahoma Academy of Science, Chickasha, OK.
3	Beadles, E., Batka, J., Stover, A., Dzindolet, M., & Pierce, L. (2003, November). *Linguistic style is related to face-to-face group performance on several different tasks*. Poster session presented at Research Day for Oklahoma's Regional Universities, Edmond, Oklahoma.
4	Study was performed by Toshihiko Nakui and Dr. Paul Paulus at the University of Texas at Arlington. Data has not yet been published.
5	Study was performed by Toshihiko Nakui and Dr. Paul Paulus at the University of Texas at Arlington. Data has not yet been published.
6	Putman, V. L. (2002). Effects of additional rules and dominance on brainstorming and decision making. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 62*, 6026.
7	Dzindolet, M. T., Paulus, P. B., & Fleek, M. (1997, April). *Improving brainstorming performance*. Poster session presented at the meeting of the Southwestern Psychological Association, Fort Worth, Texas.
8	Dzindolet, M. T., Paulus, P. B., & Fleek, M. (1997, April). *Improving brainstorming performance*. Poster session presented at the meeting of the Southwestern Psychological Association, Fort Worth, Texas.
9	Oxley, N. L., Dzindolet, M. T., & Paulus, P. B. (1996). The effects of facilitators on the performance of brainstorming groups. *Journal of Social Behavior and Personality, 11*, 633-646.
10	Burnett, S., & Dzindolet, M. T. (2002, April). *Linguistic analysis as a measure of cohesion.* Paper presented at the 20th annual Oklahoma Psychological Society Spring Research Conference, Edmond, Oklahoma.

[2]Portions of the method and results section are taken from Dzindolet, M. T., Stover, A., & Pierce, L. G. (September, 2005). Predicting Group Decision-Making with a Computerized Text Analysis Tool. In *Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting*, Santa Monica, CA: Human Factors and Ergonomics Society.

Table 1. Identifying Characteristics of the Ten Brainstorming Studies.

Study	Group Size	Time to Brain-storm	Group Cohesion	Research Location/Part	Comm Medium	Problem	# of groups
1	4	10 min	Ad Hoc	Cameron Univ. students	Face-to-Face	Thumbs	15
2	4	10 min	Ad Hoc	Cameron Univ. students	Distributed	Thumbs	15
3	2	10 min	Ad Hoc	Cameron Univ. students	Face-to-Face	Thumbs	15
4	3 or 4	20 min	Ad Hoc	UTA students	ShareWare	Improve University	22
5	3 or 4	20 min	Ad Hoc	UTA students	ShareWare	Improve University	52
6	3	20 min	Ad Hoc	UTA students	Face-to-Face	Improve University	20
7	4	45 min	Ad Hoc	Cameron Univ. students	Face-to-Face	Ecology	12
8	2	45 min	Ad Hoc	Cameron Univ. students	Face-to-Face	Ecology	14
9	4	20 min	Ad Hoc	Cameron Univ. students	Face-to-Face	Create University	40
10	3	5 min	Established	Walmart and City National Bank employees	Face-to-Face	Teenage Activities	20

Table 2. Materials for the Group Polarization Task

Choice Dilemma Questionnaire

For the following 12 questions, indicate the lowest probability of succeeding that you would accept before recommending that the more risky course of action be chosen.

- 1 chance in 10 of succeeding
- 3 chances in 10 of succeeding
- 5 chances in 10 of succeeding
- 7 chances in 10 of succeeding
- 9 chances in 10 of succeeding
- I would not recommend taking the chance

___1. An electrical engineer may stick with his present job at a modest but adequate salary, or may take a new job offering considerably more money but no long-term security.

___2. A man with a severe heart ailment must seriously curtail his customary way of life if he does not undergo a delicate medical operation which might cure him completely or might prove fatal.

___3. A man of moderate means may invest some money he recently invested in secure "blue chip" low return securities, or in more risky securities that offer the possibility of large gains.

___4. A captain of a college football team in the final seconds of the game with the college's traditional rival may choose a play that is almost certain to produce a tie score or a more risky play that would lead to victory if successful; sure defeat if not.

___5. The president of an American corporation which is about to expand may build a new plant in the United States where returns on the investment would be moderate, or may decide to build in a foreign country with an unstable political history where, however, returns on the investment would be very high.

___6. A college senior planning graduate work in chemistry may enter University X where, because of rigorous standards, only a fraction of the graduate students manage to receive their PhD, or may enter University Y which has a poorer reputation but where almost every graduate student receives a PhD.

___7. A low ranked participant in a national chess tournament playing an early match with the top favored player has the choice of whether or not to try a deceptive but risky maneuver which might lead to quick victory if successful or almost certain defeat if it fails.

___8. A college senior with considerable musical talent must choose between the secure course of going to medical school and becoming a physician or, the risky course of embarking on the career of a concert pianist.

___9. An American prisoner of war in World War II must choose between possible escape with the risk of execution if caught, or resting in the camp where privations are severe.

___10. A successful businessman with strong feelings of civic responsibility must decide whether or not to run for congress on the ticket for a minority party whose campaign funds are limited.

___11. A research physicist just beginning a 5-year appointment at a university may spend time working on a series of short term problems which he would be sure to solve, but which would be of lesser importance, or an a very important, but very difficult problem with the risk of nothing to show for his 5 years of effort.

___12. An engaged couple must decide in the face of recent arguments suggesting some sharp differences of opinion, whether or not to get married. Discussions with a marriage counselor indicate that a happy marriage while possible would not be assured.

Table 3. Payoff Matrix for the Adapted Prisoner's Dilemma Task.

	Partner 1	Partner 2	Partner 3
Option 1	Decision: Blue $ 4.00	Decision: Blue $ 4.00	Decision: Blue $ 4.00
Option 2	Decision: Green $ 5.00	Decision: Green $ 5.00	Decision: Green $ 5.00
Option 3	Decision: Green $ 3.00	Decision: Blue $ 7.00	Decision: Green $ 3.00
Option 4	Decision: Green $ 1.00	Decision: Blue $ 5.00	Decision: Blue $ 5.00
Option 5	Decision: Blue $ 7.00	Decision: Green $ 3.00	Decision: Green $ 3.00

Table 4. Overall Summary of Significant Word Category-Group Performance Correlations Across All Studies

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Pronouns				-	-	-	-		-		(-)											(+)	
1st Pers Sing			-		-	-	-		-					+								(+)	
1st Person Plural																							
Second Pers											(-)		-	+				(-)	(-)			(+)	
Third Person							(-)					(+)											
Six + letters					+		(-)	+			(+)												+
Causal								-	-				?	+									(-)
Negate		(-)	(-)				(-)			(-)	(-)			(-)								(+)	
Exclusive				-		-	-		-		(+)		-						(+)			(+)	(-)
Inclusive							-		-														
Articles											(-)											(-)	
Prepositions											-	-	-									-	(+)
Numbers								(-)			+			(+)									(+)
Positive Emo					+		-	(+)											(+)				
Positive Feel							-	+												(+)		(+)	
Optimistic					+																		
Negative Emotions		-	-									(+)		-					(+)				
Anxiety																							
Anger																			(+)			(-)	(+)
Sad							-	(-)				(+)											
Cognitive Mechanisms	(-)				-				-													(+)	(-)
Insight	-	-				-			-					(-)									
Discrepancy					-						(-)							+	(+)				(-)
Social Mech							-				(-)		-				-					(+)	
Communic		(-)					-	(-)			(-)			(+)			-	(+)		(-)			
Past Tense						-	+	-	-		(+)	(+)		+									
Present Tense	(-)		-		-		(-)		-		(-)		-	-								(+)	(-)
Future Tense													-				+	(+)	(-)				(-)

Key: + means significant positive correlation with performance; (+) means trend for positive correlation with performance (i.e., r > .50); - means significant negative correlation with performance; (-) means trend for negative correlation with performance (i.e., r < -.50).

Study 1 = Face-to-Face Group of 4 Brainstorming Thumbs Problem
Study 2 = Distributed Group of 4 Brainstorming Thumbs Problem
Study 3 = Face-to-Face Dyad Brainstorming Thumbs Problem
Study 4 = Share Ware Group of 3 or 4 Brainstorming Improve University Problem
Study 5 = Share Ware Group of 3 or 4 Brainstorming Improve University Problem
Study 6 = Face-to-Face Group of 3 Brainstorming Improve University Problem
Study 7 = Face-to-Face Group of 4 Brainstorming Ecology Problem
Study 8 = Face-to-Face Dyad Brainstorming Ecology Problem
Study 9 = Face-to-Face Group of 4 Brainstorming Create University Problem
Study 10 = Face-to-Face Group of 3 Brainstorming Teenage Activities Problem
Study 11 = Face-to-Face Dyad Desert Survival Task
Study 12 = Face-to-Face Group of 3 Desert Survival Task
Study 13 = Face-to-Face Dyad Hidden Profile Task
Study 14 = Face-to-Face Group of 4 Hidden Profile Task
Study 15 = Distributed Group of 4 Group Polarization Task
Study 16 = Face-to-Face Group of 4 Group Polarization Task
Study 17 = Face-to-Face Dyad Group Polarization Task
Study 18 = Distributed Group of 3 Prisoner's Dilemma Task
Study 19 = Face-to-Face Group of 3 Prisoner's Dilemma Task
Study 20 = Distributed Dyad Prisoner's Dilemma Task
Study 21 = Face-to-Face Group of 3 House of Cards Task
Study 22 = Face-to-Face Dyad Radio Assembly Task
Study 23 = Face-to-Face Group of 3 Radio Assembly Task

Figure 1. McGrath's Circumplex of Group Tasks

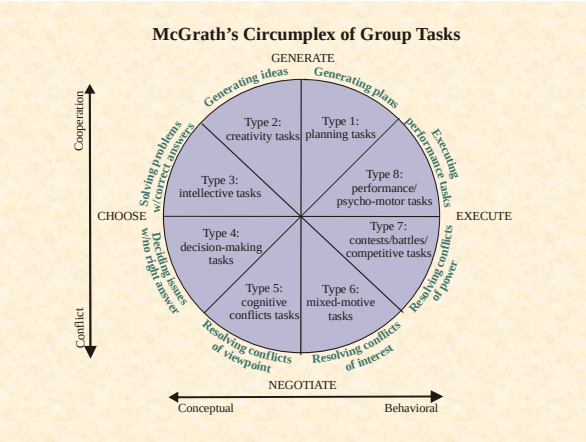

Figure 2. Brainstorming Task: Total Pronouns (I, our, they, you, we)

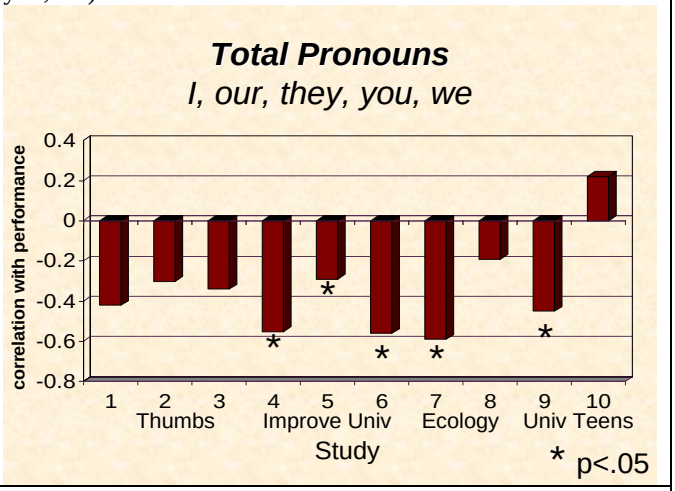

Figure 3. Brainstorming Task: First Person Singular Pronouns (I, me, my)

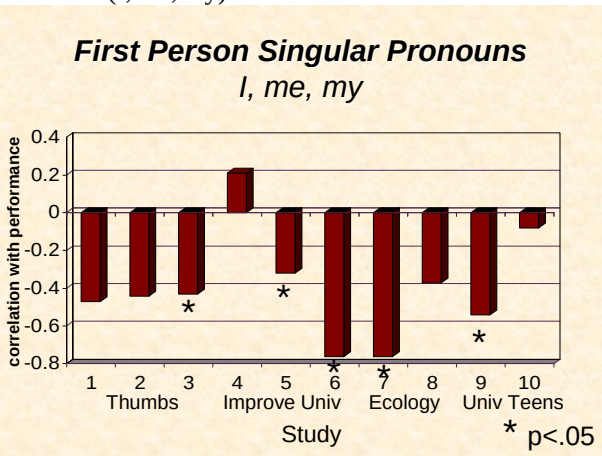

Figure 4. Brainstorming Task: First Person Plural Pronouns (we, our, us)

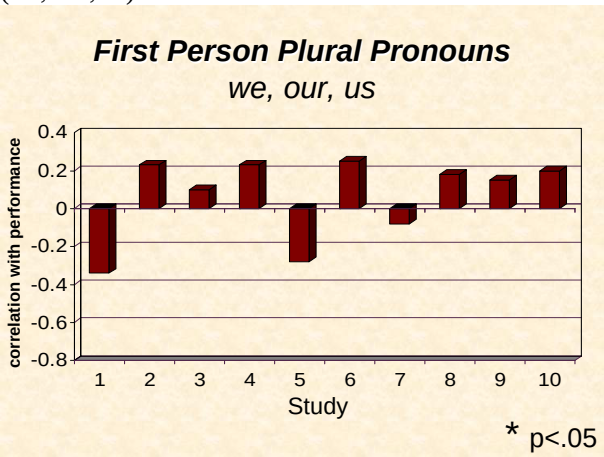

Figure 5. Brainstorming Task: Second Person Pronouns (you, your, y'all)

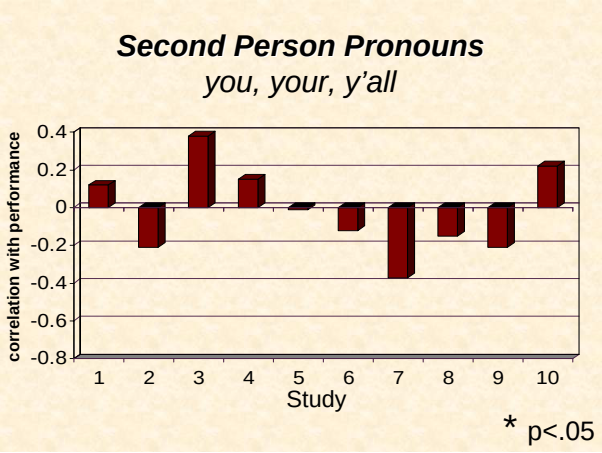

Figure 6. Brainstorming Task: Third Person Pronouns (he, she, they)

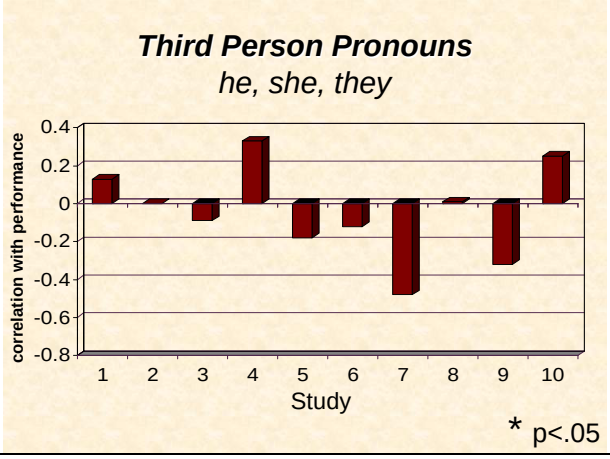

Figure 7. Brainstorming Task: References to Other People (anyone, everybody, someone)

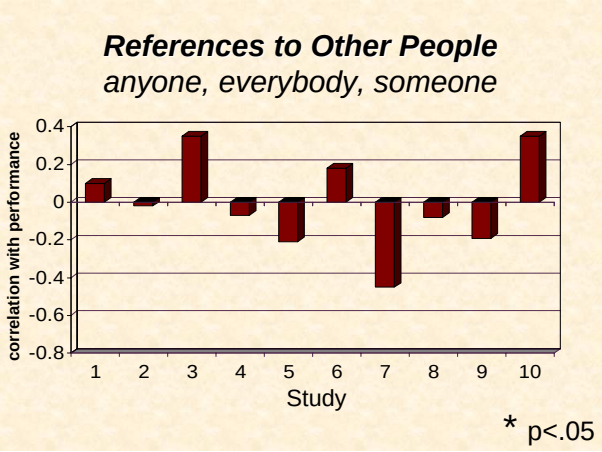

Figure 8. Brainstorming Task: Tentative Words (maybe, perhaps, depending)

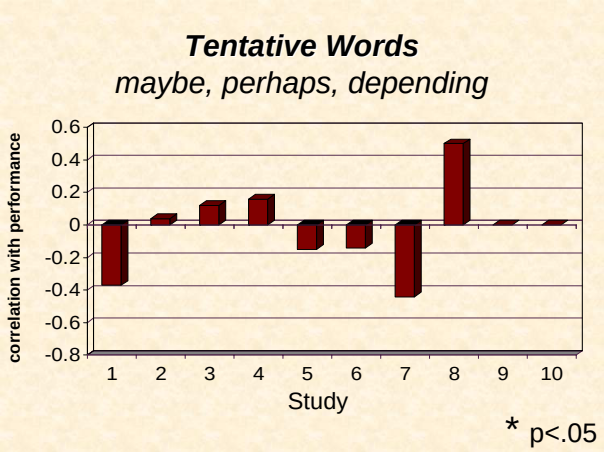

Figure 9. Brainstorming Task: Certainty Words (clearly, always, confidently)

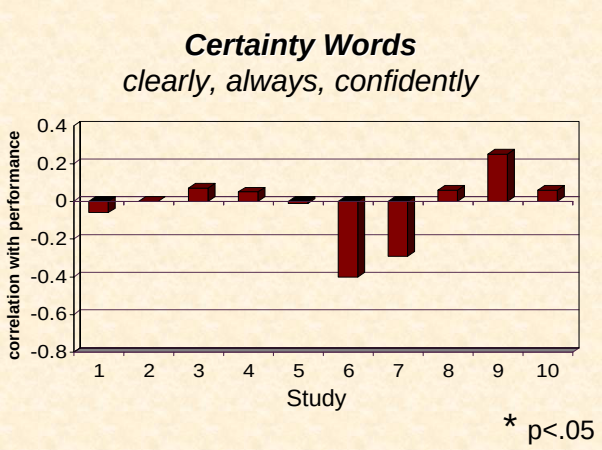

Figure 10. Brainstorming Task: Negate (no, never, not)

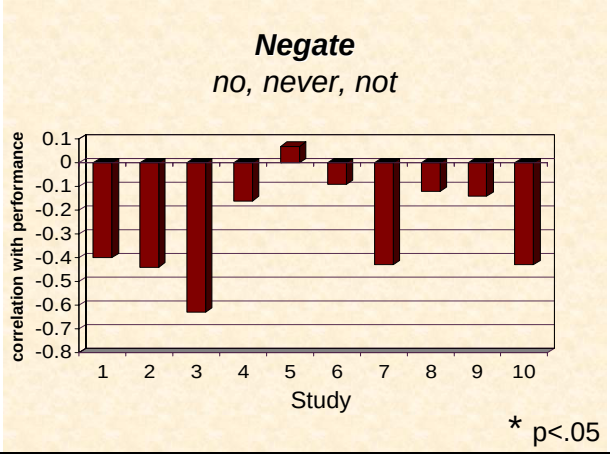

Figure 11. Brainstorming Task: Assent (yes, okay, alright, agree)

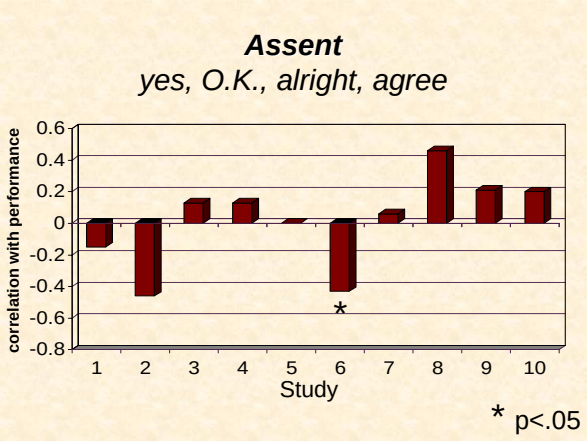

Figure 12. Brainstorming Task: Words with Six or More Letters

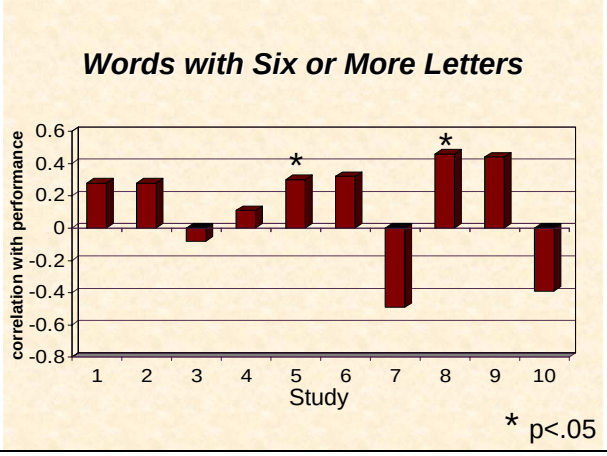

Figure 13. Brainstorming Task: Causal Words (because, since, basis)

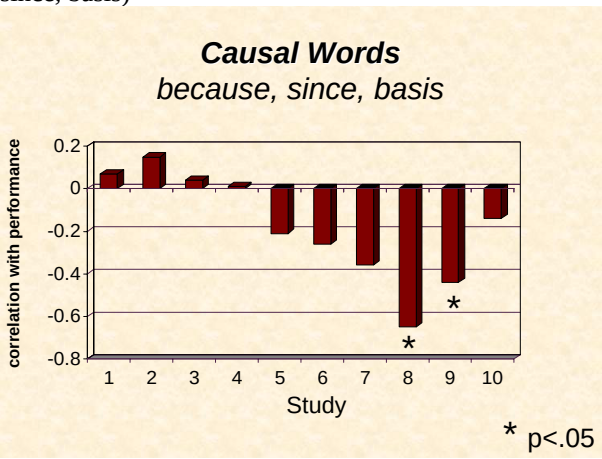

Figure 14. Brainstorming Task: Exclusive Words (but, except, without)

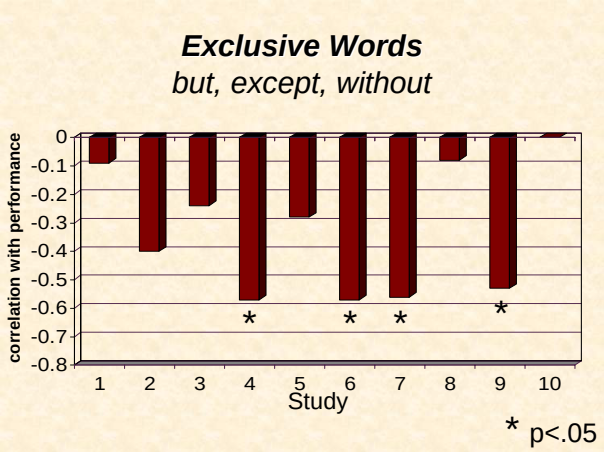

Figure 15. Brainstorming Task: Inclusive Words (together, with, also)

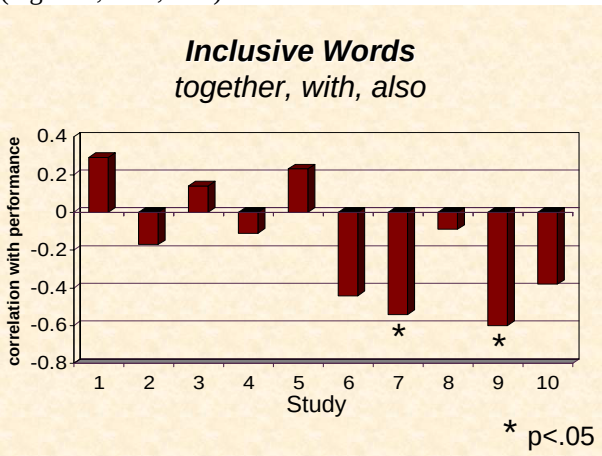

Figure 16. Brainstorming Task: Articles (a, an, the)

Figure 17. Brainstorming Task: Prepositions (to, for, at)

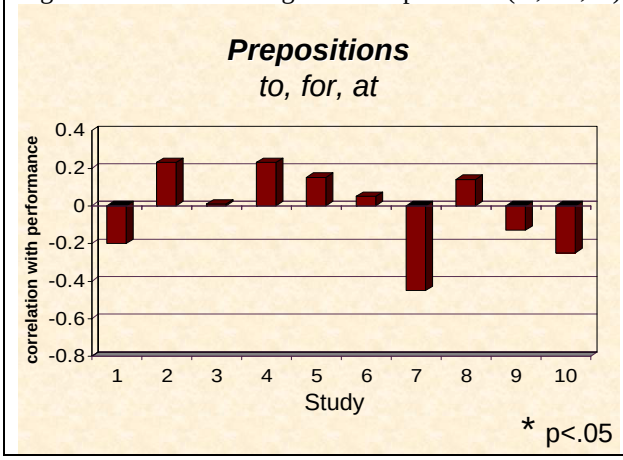

Figure 18. Brainstorming Task: Numbers

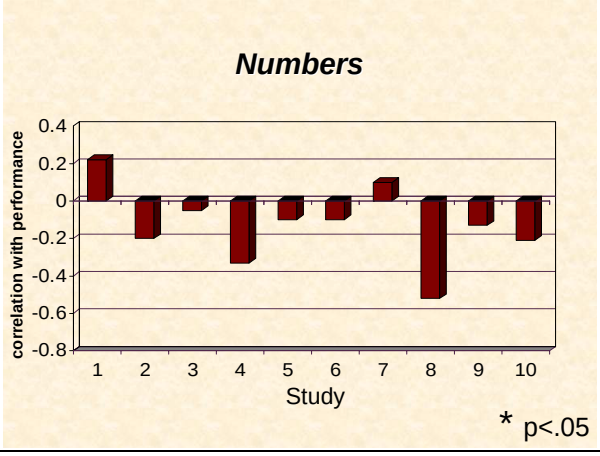

Figure 19. Brainstorming Task: Positive Emotion Words (happy, pretty, good)

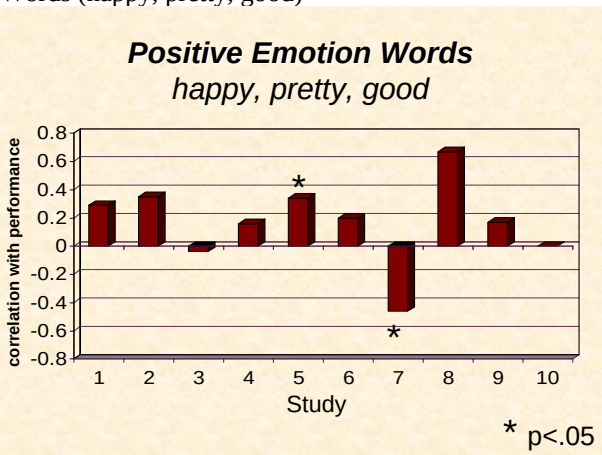

Figure 20. Brainstorming Task: Words Expressing Positive Feelings (care, encourage, enjoy)

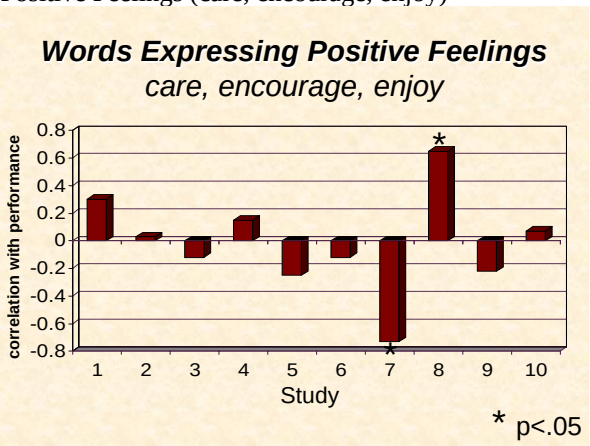

Figure 21. Brainstorming Task: Optimistic Words (hope, best, win)

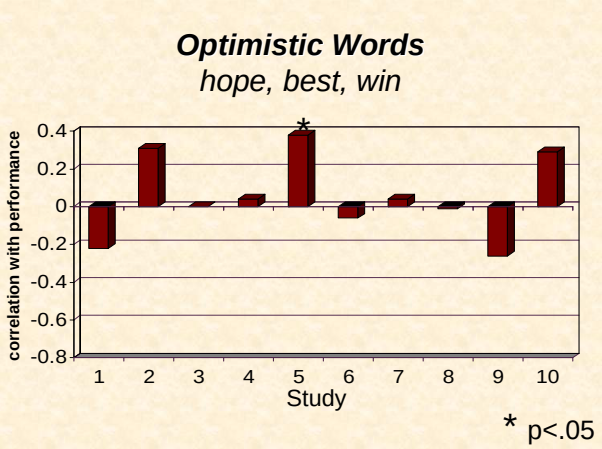

Figure 22. Brainstorming Task: Negative Emotion Words (hate, worthless, ugly)

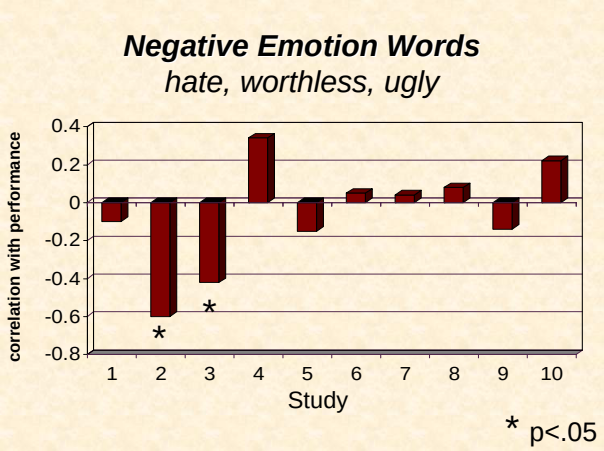

Figure 23. Brainstorming Task: Anxiety Words (nervous, scared, anxious)

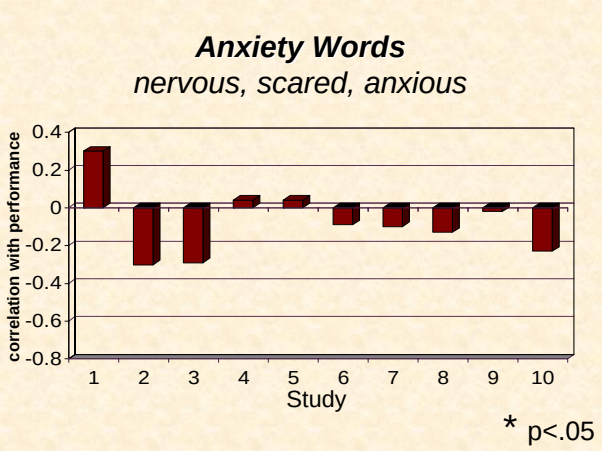

Figure 24. Brainstorming Task: Words Expressing Anger (jerk, kill, annoy)

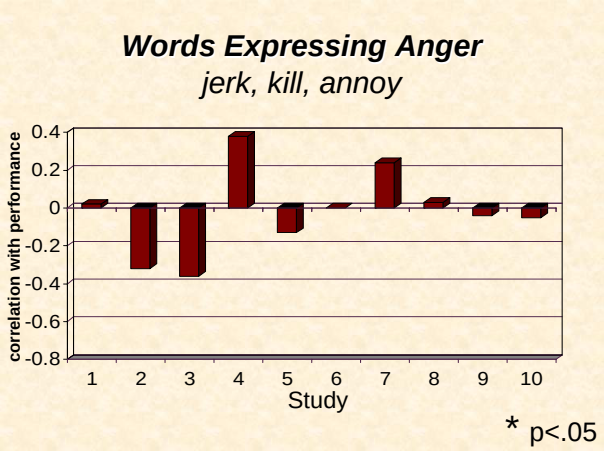

Figure 25. Brainstorming Task: Words Expressing Sadness (sad, upset, suffer)

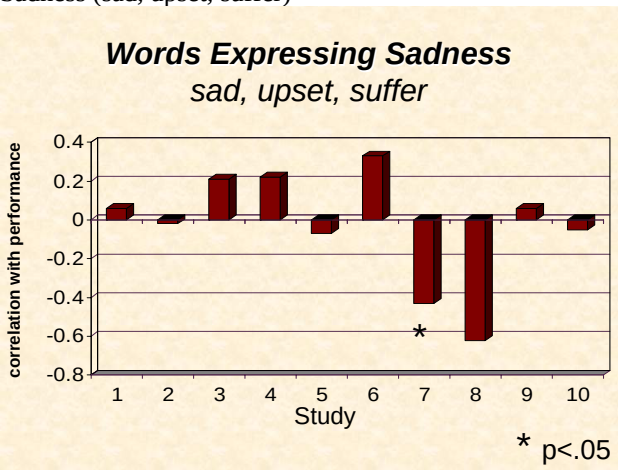

Figure 26. Brainstorming Task: Discrepancy Words (should, ought, could)

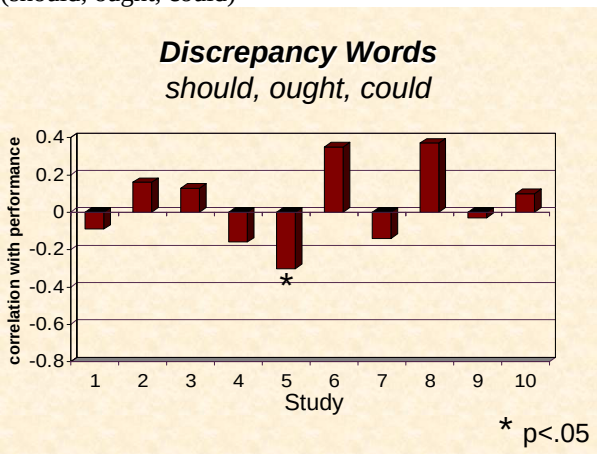

Figure 27. Brainstorming Task: Social Mechanisms (friend, phone, gossip, group)

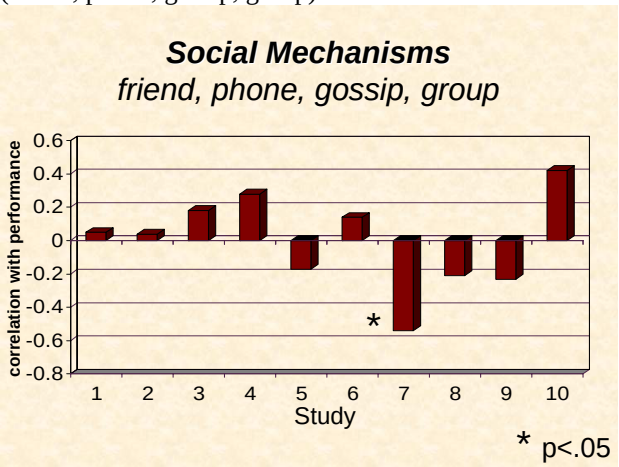

Figure 28. Brainstorming Task: Communication Words (talk, ask, chat, counsel)

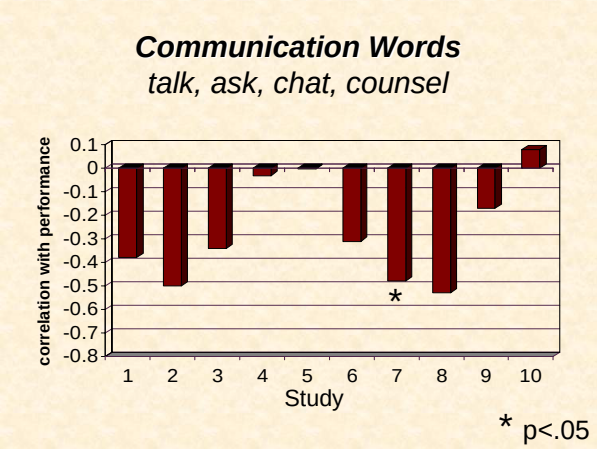

Figure 29. Brainstorming Task: Cognitive Mechanisms (questioning, acknowledge, inform)

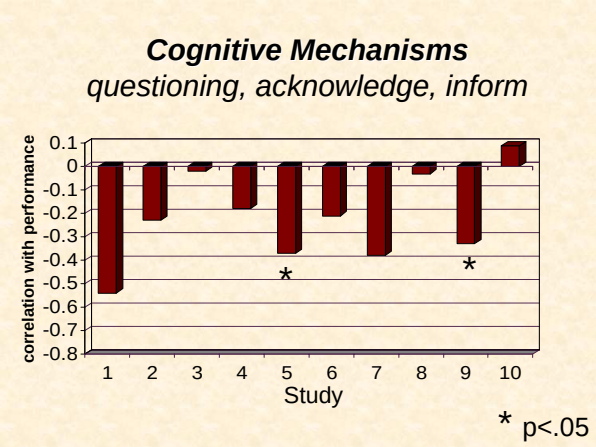

Figure 30. Brainstorming Task: Insight Words (think, know, believe)

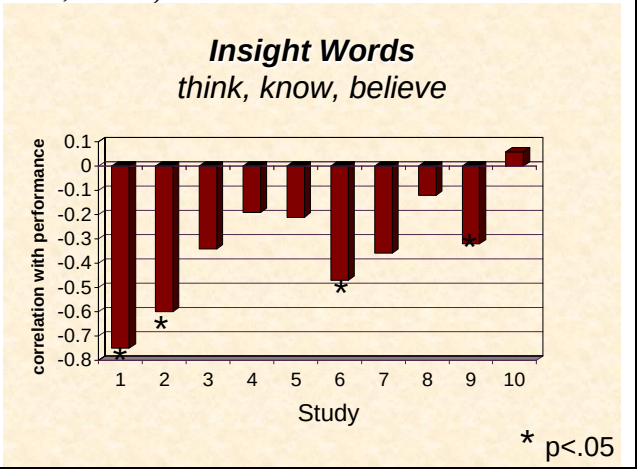

Figure 31. Brainstorming Task: Past Tense

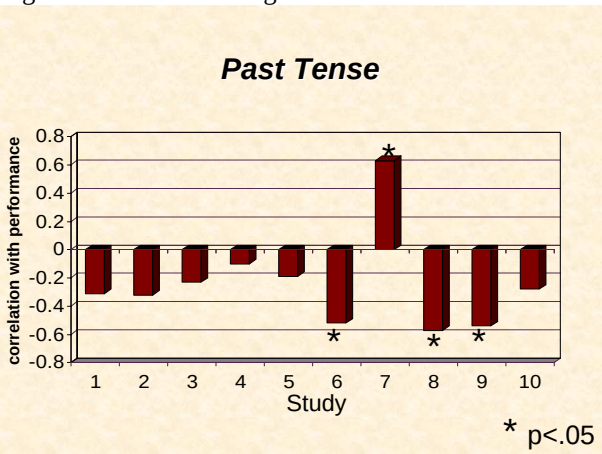

Figure 32. Brainstorming Task: Present Tense

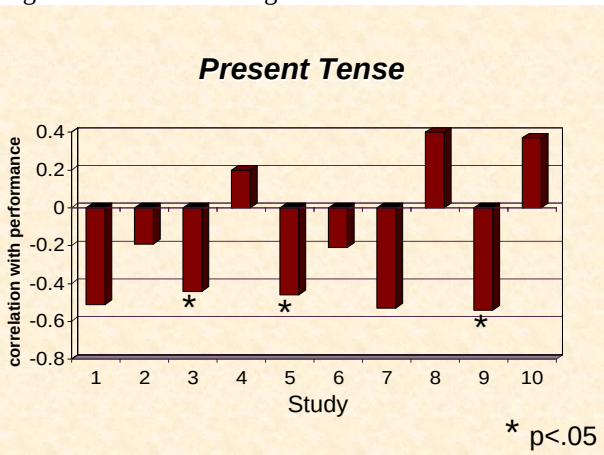

Figure 33. Brainstorming Task: Future Tense

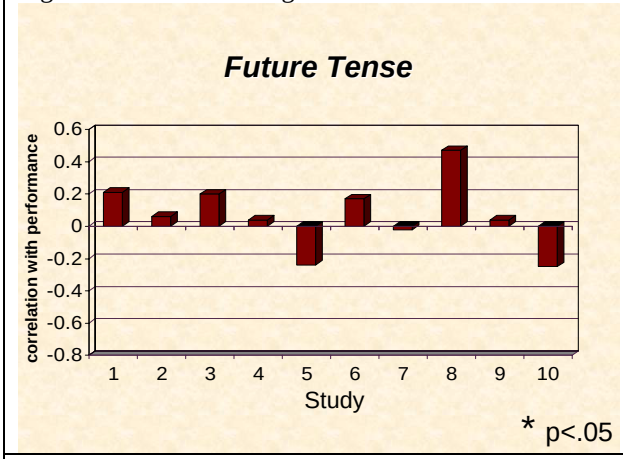

Figure 34. Desert Survival Task: Pronoun Use

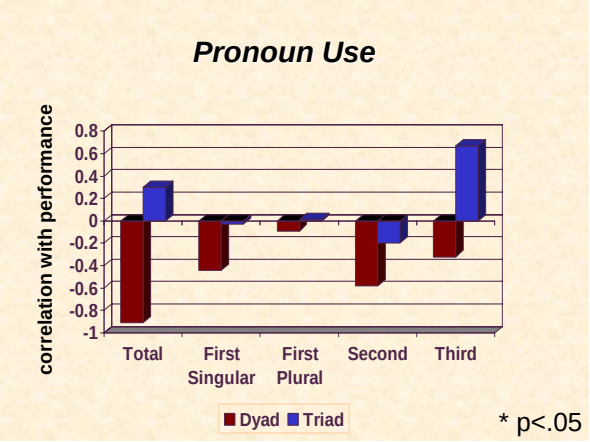

Figure 35. Desert Survival Task: Cognitive Complexity

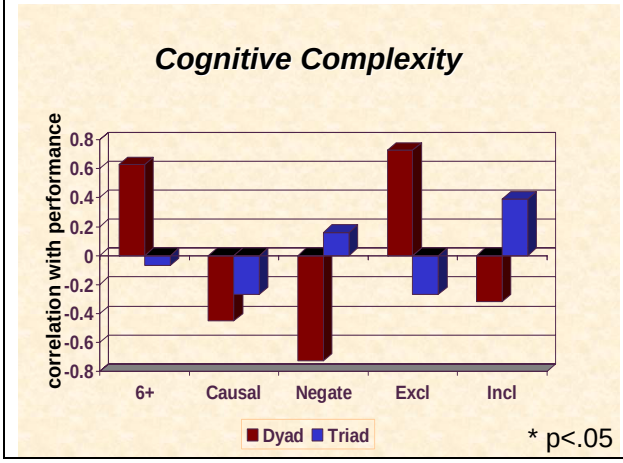

Figure 36. Desert Survival Task: Cognitive Complexity (Concrete Words)

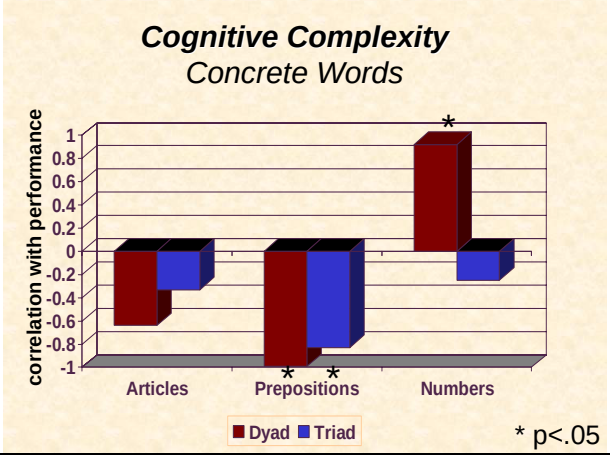

Figure 37. Desert Survival Task: Words Expressing Emotion

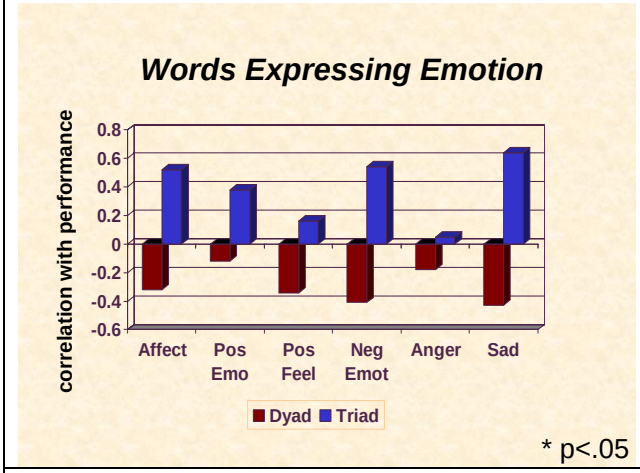

Figure 38. Desert Survival Task: Cognitive & Social Processes

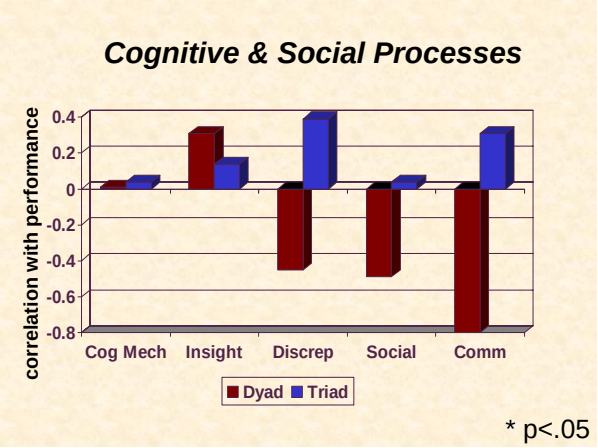

Figure 39. Desert Survival Task: Tense

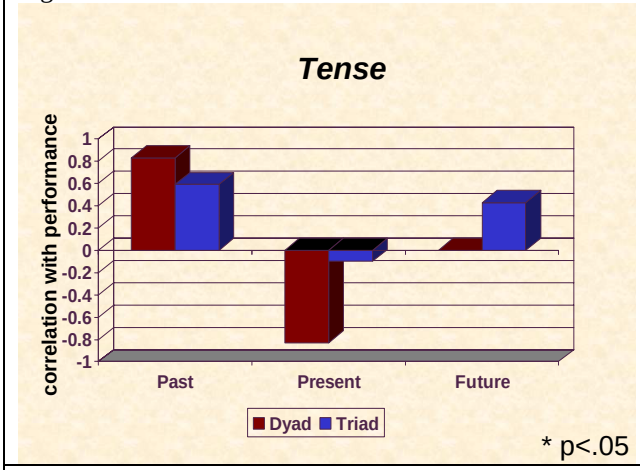

Figure 40. Hidden Profile Task - Shared: Pronoun Use

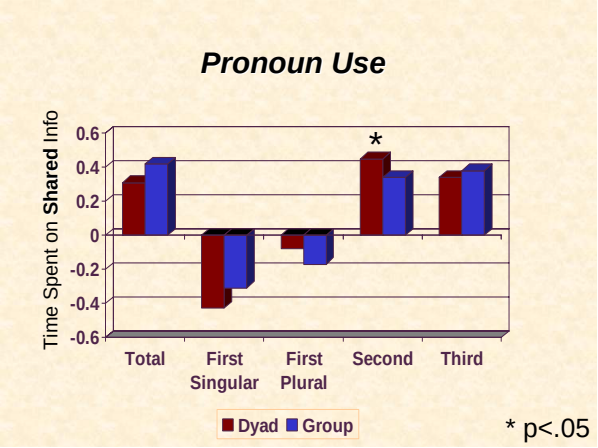

Figure 41. Hidden Profile Task - Unique: Pronoun Use

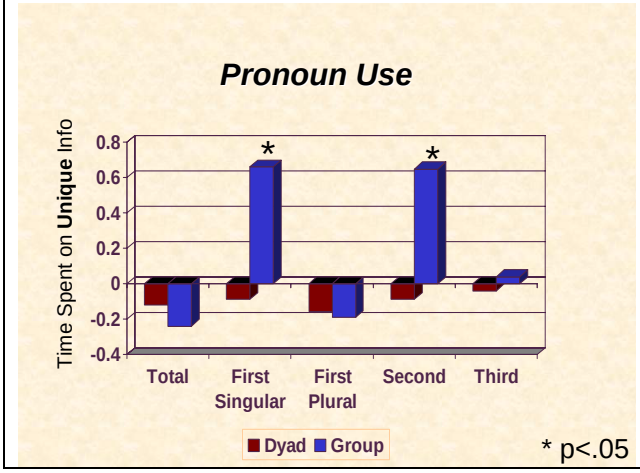

Figure 42. Hidden Profile Task - Shared: Cognitive Complexity

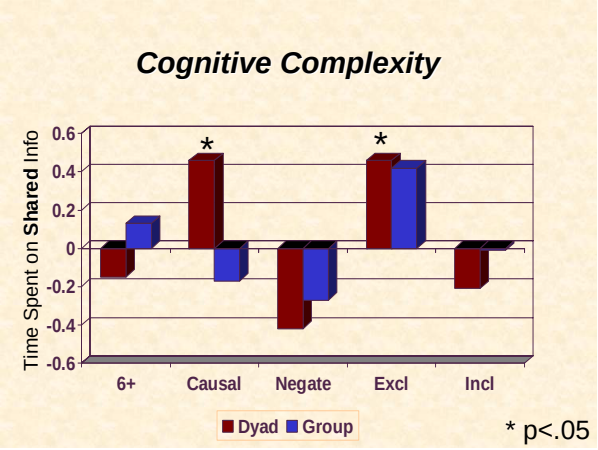

Figure 43. Hidden Profile Task - Unique: Cognitive Complexity

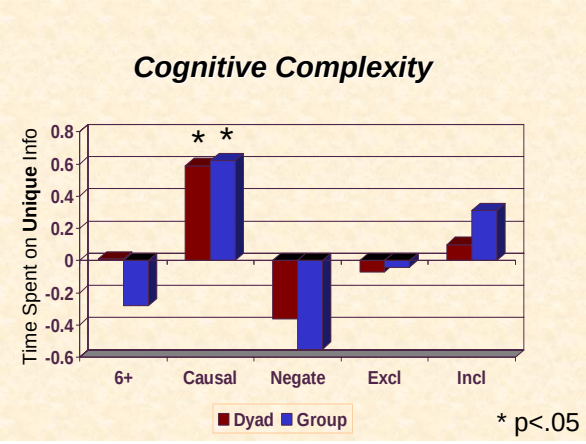

Figure 44. Hidden Profile Task - Shared: Cognitive Complexity (Concrete Words)

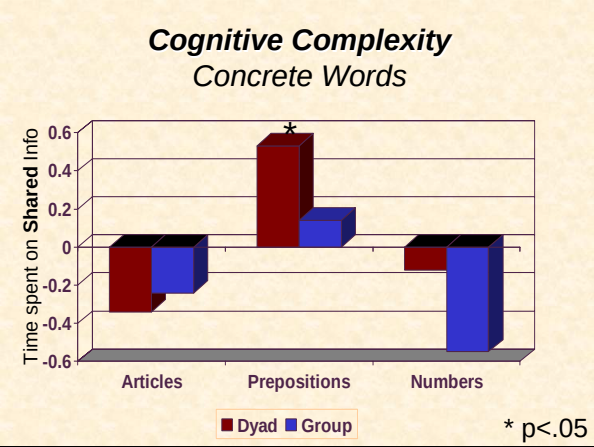

Figure 45. Hidden Profile Task - Unique: Cognitive Complexity (Concrete Words)

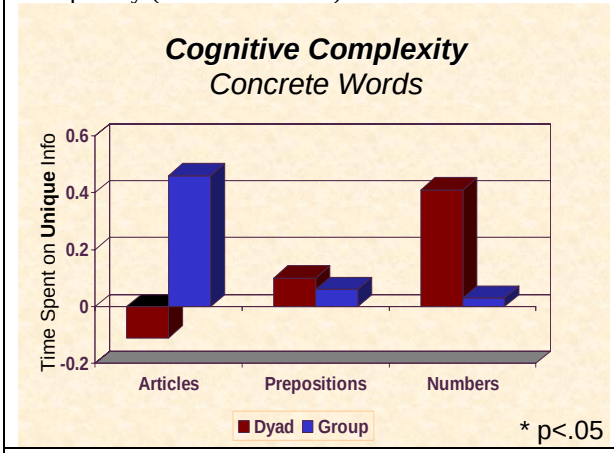

Figure 46. Hidden Profile Task - Shared: Words Expressing Emotion

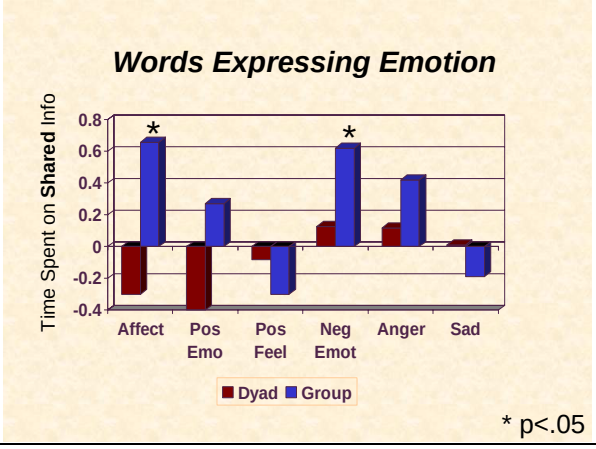

Figure 47. Hidden Profile Task - Unique: Words Expressing Emotion

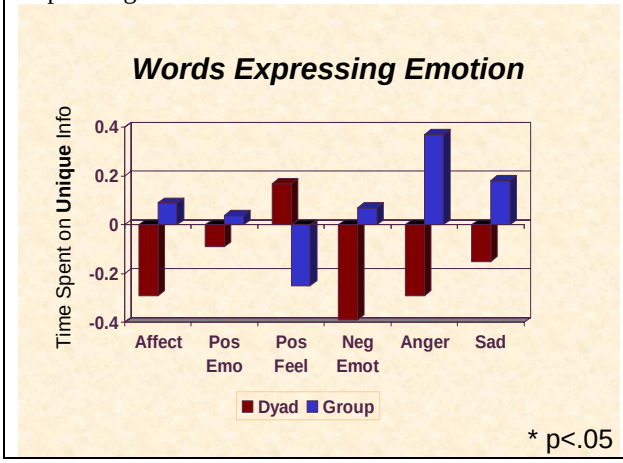

Figure 48. Hidden Profile Task - Shared: Cognitive & Social Processes

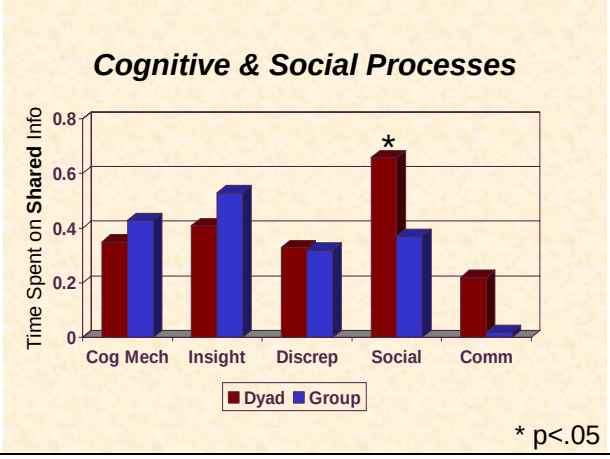

Figure 49. Hidden Profile Task - Unique: Cognitive & Social Processes

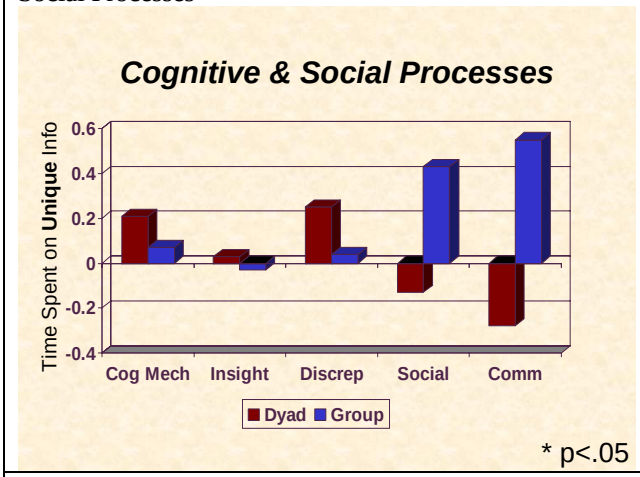

Figure 50. Hidden Profile Task - Shared: Tense

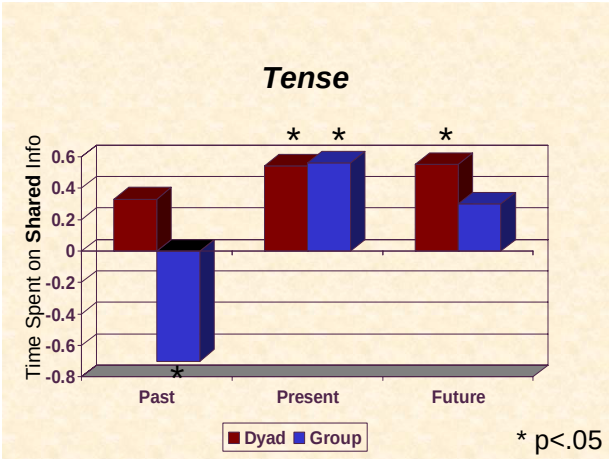

Figure 51. Hidden Profile Task - Unique: Tense

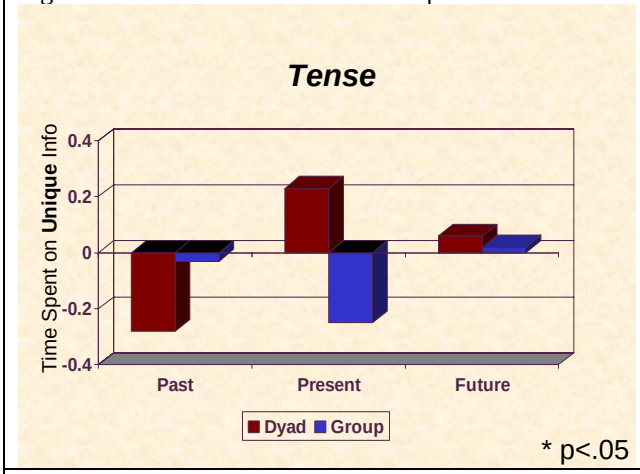

Figure 52. Group Polarization Task: Pronoun Use

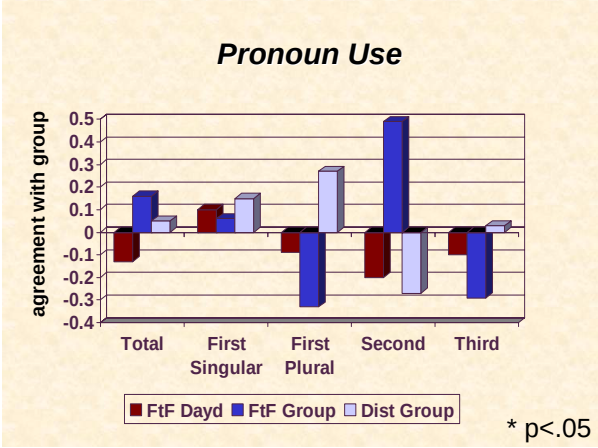

Figure 53. Group Polarization Task: Cognitive Complexity

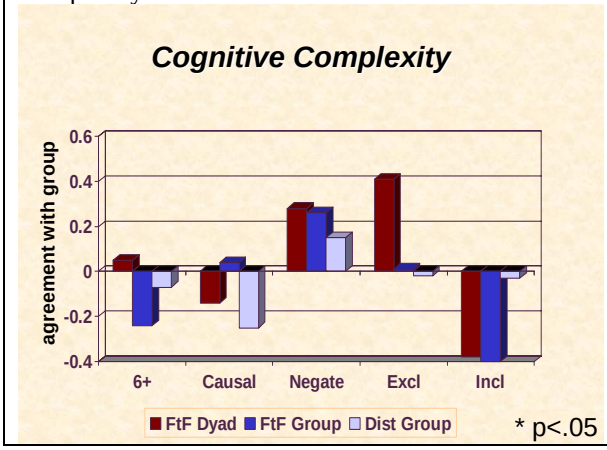

Figure 54. Group Polarization Task: Cognitive Complexity (Concrete Words)

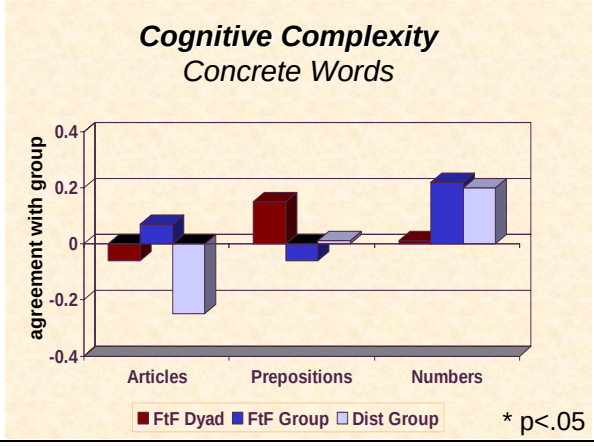

Figure 55. Group Polarization Task: Words Expressing Positive Emotions

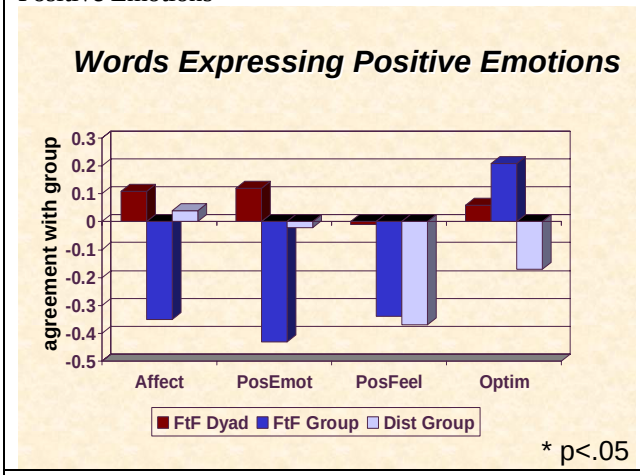

Figure 56. Group Polarization Task: Words Expressing Negative Emotions

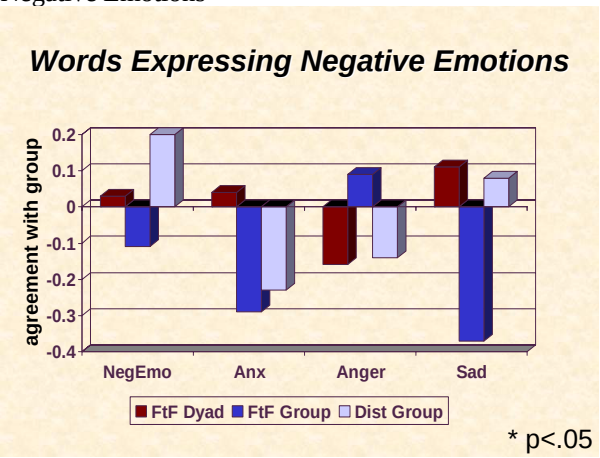

Figure 57. Group Polarization Task: Cognitive & Social Processes

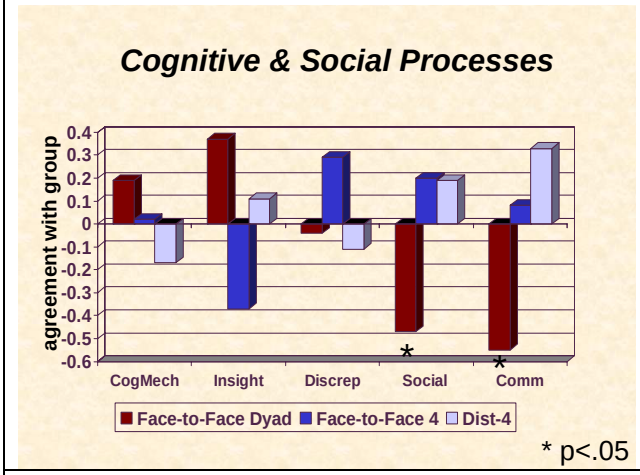

Figure 58. Group Polarization Task: Tense

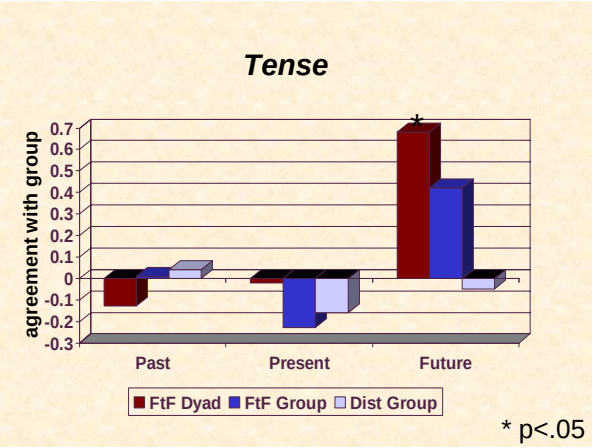

Figure 59. Prisoner Dilemma Task: Pronoun Use

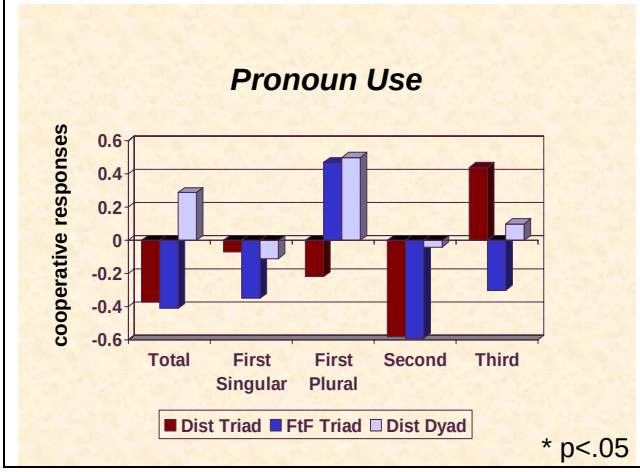

Figure 60. Prisoner Dilemma Task: Cognitive Complexity

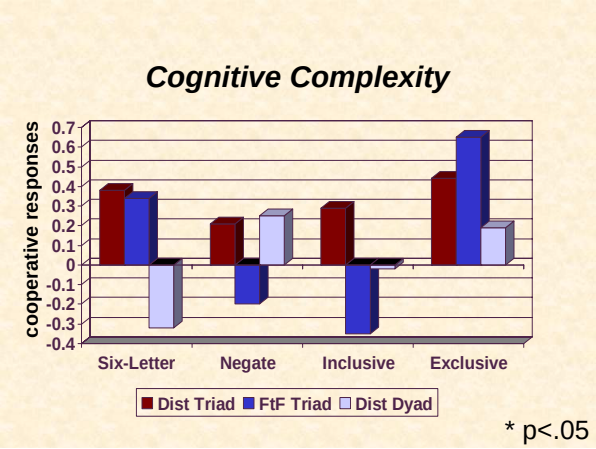

Figure 61. Prisoner Dilemma Task: Cognitive Complexity (Concrete Words)

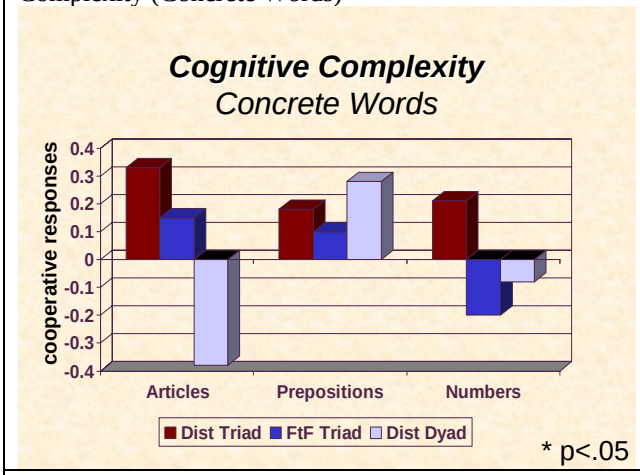

Figure 62. Prisoner Dilemma Task: Words Expressing Positive Emotions

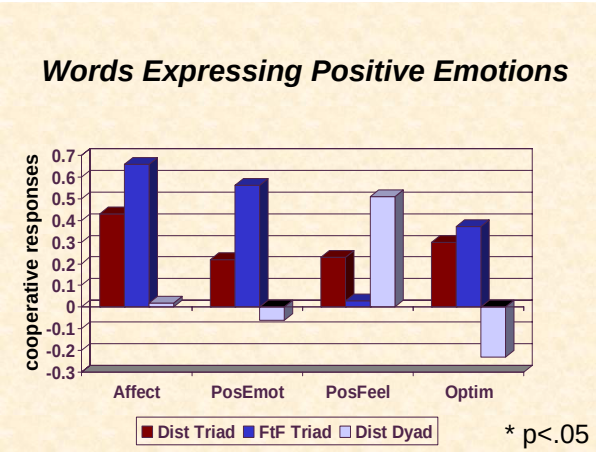

Figure 63. Prisoner Dilemma Task: Words Expressing Negative Emotions

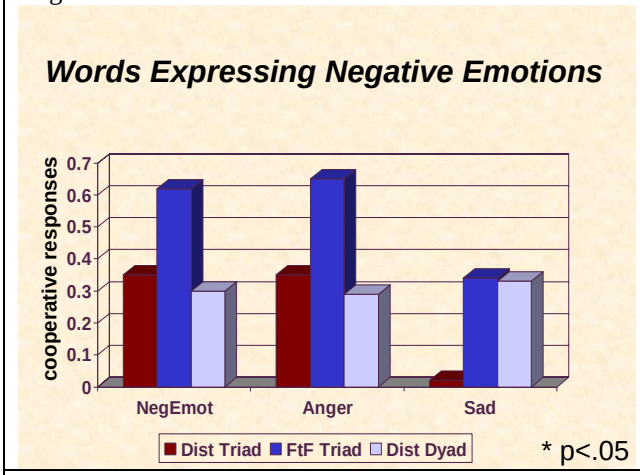

Figure 64. Prisoner Dilemma Task: Cognitive & Social Processes

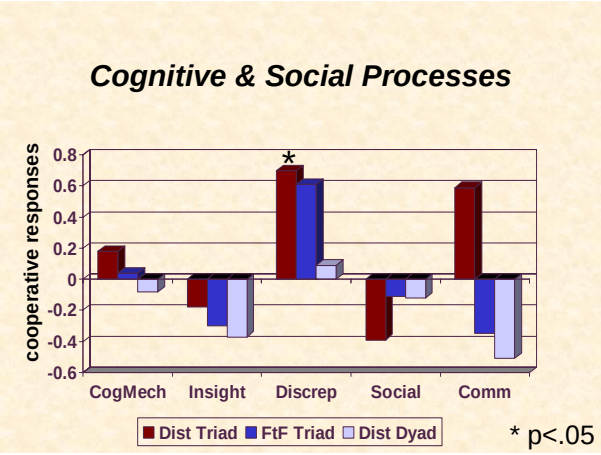

Figure 65. Prisoner Dilemma Task: Tense

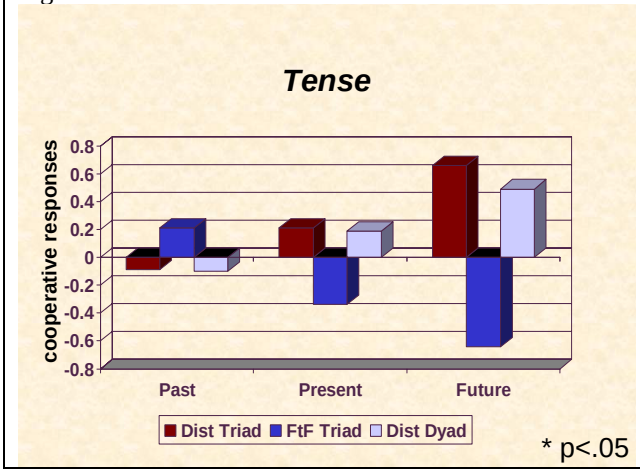

Figure 66. House of Cards Task: Pronoun Use

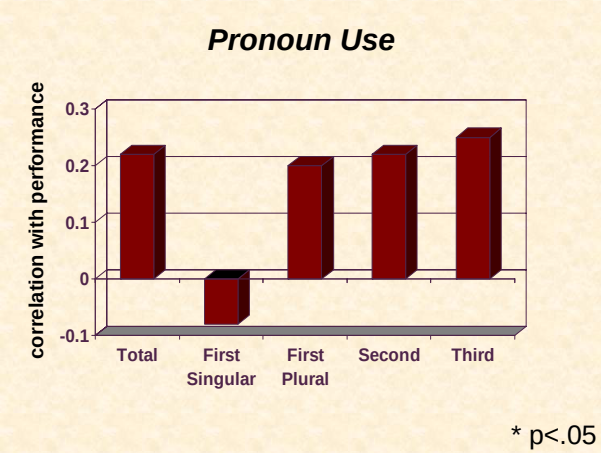

Figure 67. House of Cards Task: Cognitive Complexity

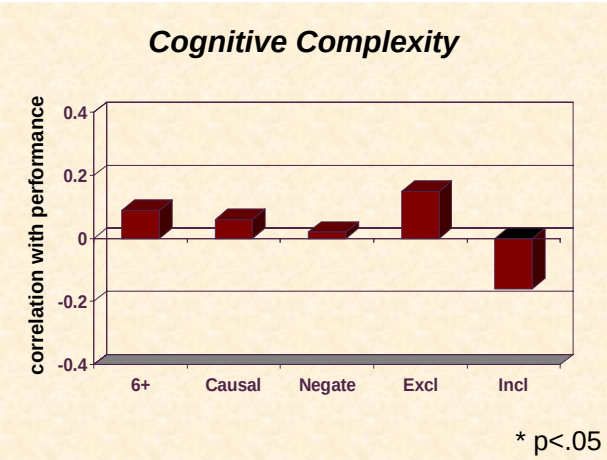

Figure 68. House of Cards Task: Cognitive Complexity (Concrete Words)

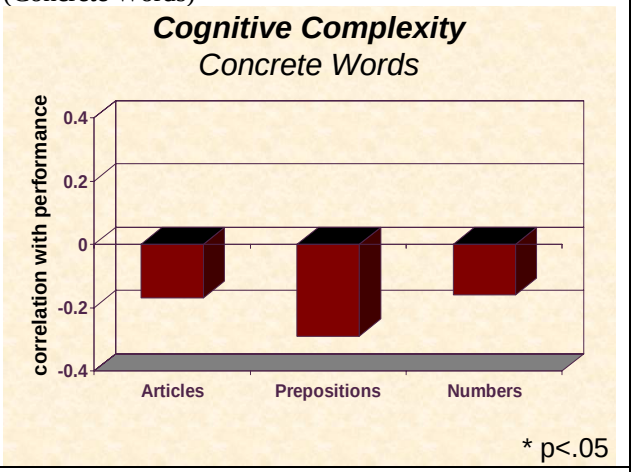

Figure 69. House of Cards Task: Words Expressing Emotions

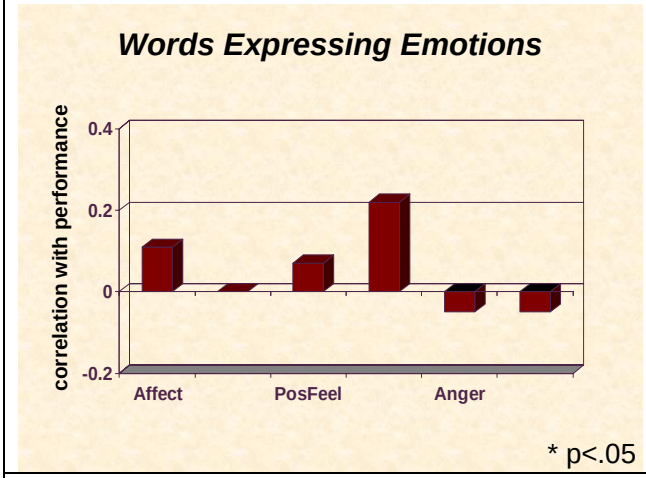

Figure 70. House of Cards Task: Cognitive & Social Processes

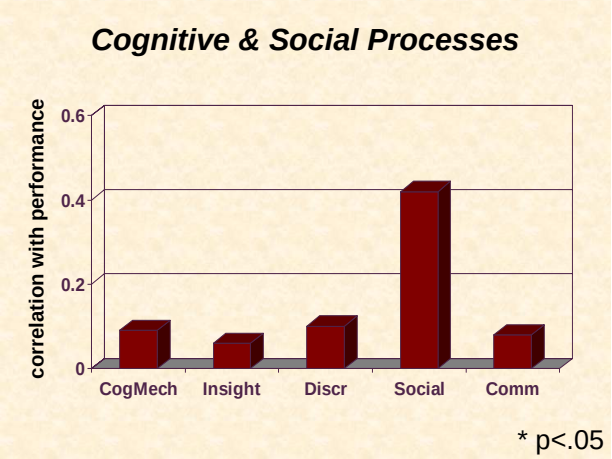

Figure 71. House of Cards Task: Tense

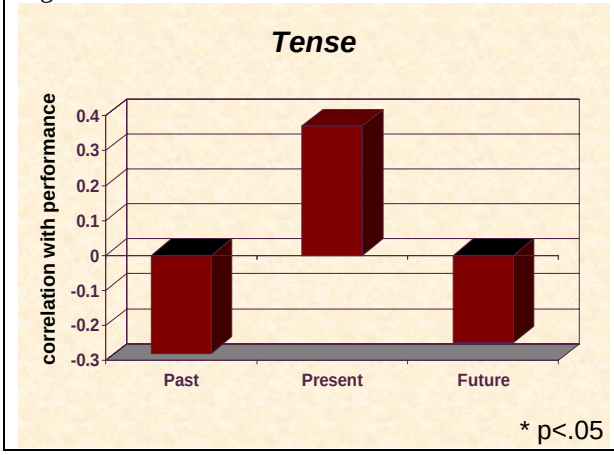

Figure 72. Radio Assembly Task: Pronoun Use

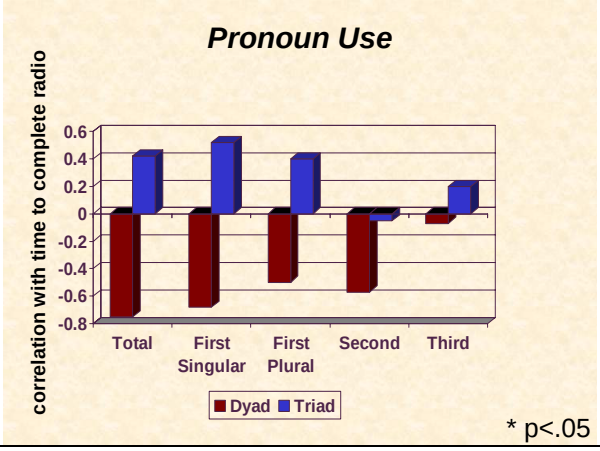

Figure 73. Radio Assembly Task: Cognitive Complexity

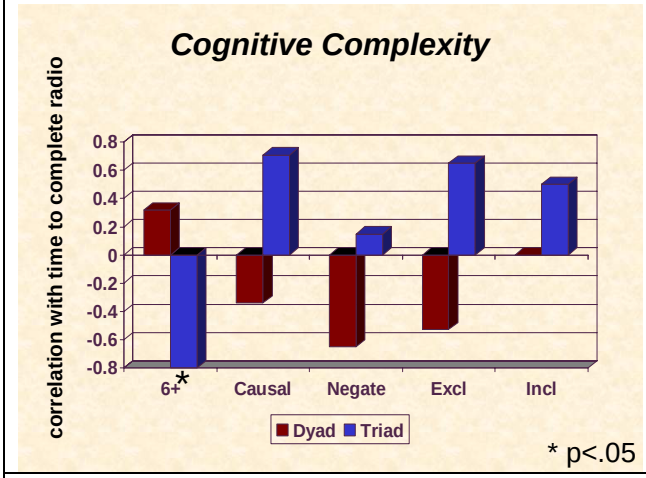

Figure 74. Radio Assembly Task: Cognitive Complexity (Concrete Words)

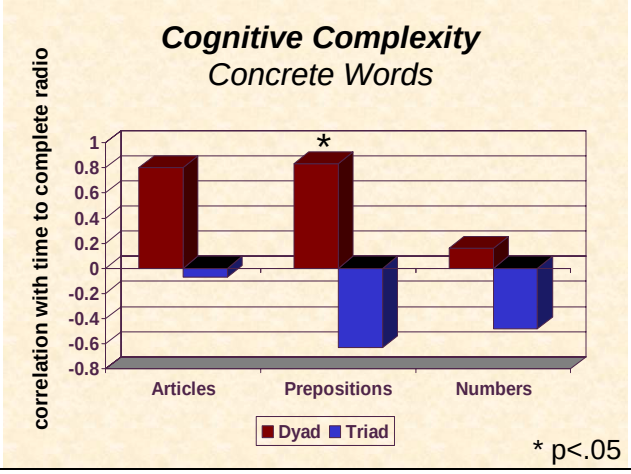

Figure 75. Radio Assembly Task: Words Expressing Positive Emotions

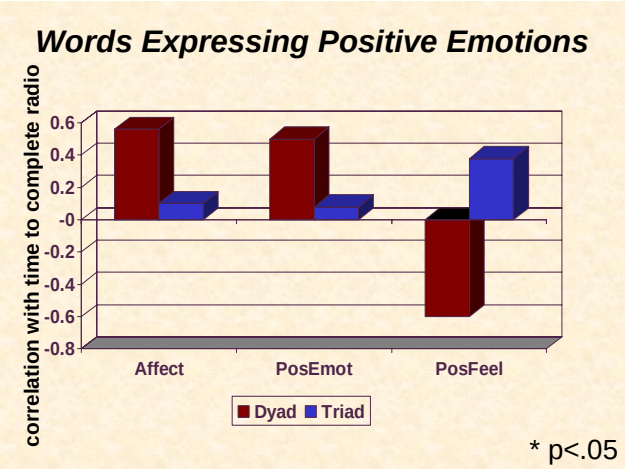

Figure 76. Radio Assembly Task: Words Expressing Negative Emotions

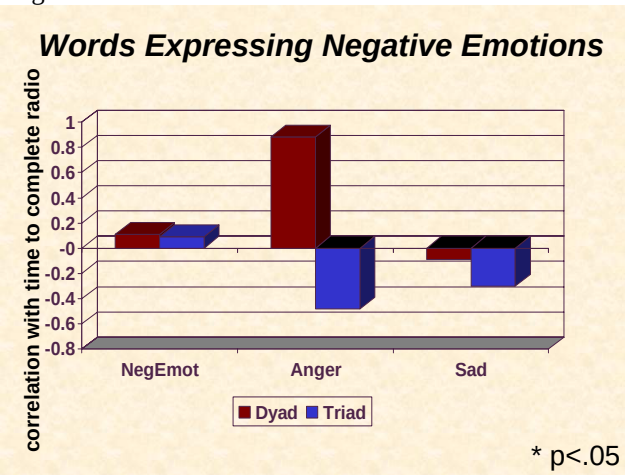

Figure 77. Radio Assembly Task: Cognitive & Social Processes

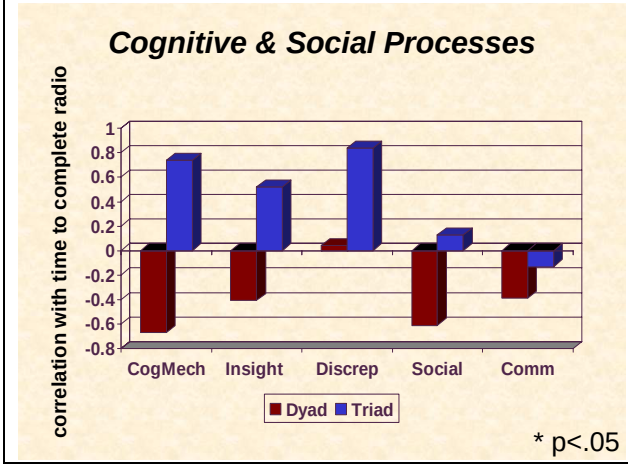
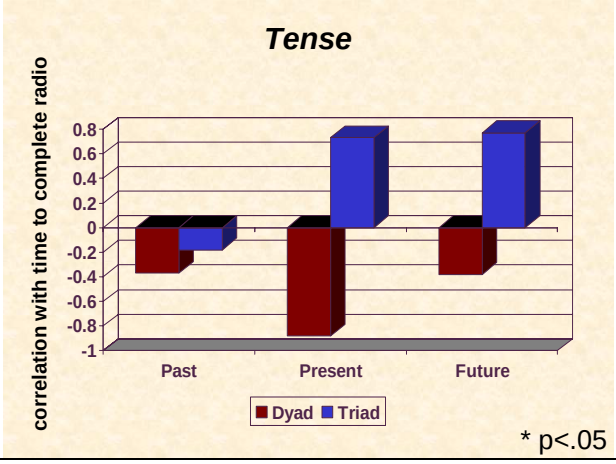
Figure 78. Radio Assembly Task: Tense