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Intrateam Communication and Performance in Doubles Tennis

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Verbal and nonverbal communication is a critical mediator of performance in team sports and yet there is little extant research in sports that involves direct measures of communication. Our study explored communication within NCAA Division I female tennis doubles teams. Video and audio recordings of players during doubles tennis matches captured the communications that took place between and during points. These recordings were coded and sequential analysis computed using the Discussion Analysis Tool software (Jeong, 2003). Results indicated that most communications were emotional (i.e., > 50%) or action statements (i.e., > 25%). Winning teams exhibited significantly different communication sequences than losing teams. In particular, winning teams had a more homogeneous model of communication, which perhaps makes message interpretation more reliable. Finally, winning teams exchanged twice as many messages as losing teams.

Key words: communication software, coordination, data analysis tool, shared mental models

Our study of the relationship between communications in tennis doubles teams and team performance was the first attempt to directly measure communication between sports team members during a competitive event and relate these measures to team performance. Communication in sport teams is considered primarily from a social perspective (Eccles & Johnson, 2007; Eccles & Tenenbaum, 2004). Researchers have looked at the effect of social constructs on communication, or vice versa. For example, Carron and Hausenblas (1998) reviewed evidence of how intrateam communication is effective to the extent that the team is homogenous in terms of characteristics, such as age and educational attainments. Communication also is studied in terms of its effect on team cohesion and conflict, and in terms of social pressure and conformity (Carron & Hausenblas, 1998). Recommendations for improving team communication include creating opportunities for team member socializing and promoting discussions, which can enhance team cohesion (Carron & Spink, 1993). Sullivan and Feltz (2003) provided the only current measure of communication in sport, which pertains predominantly to aspects of team cohesion. They used self-report measures of communication, which ask about general communication styles.

To our knowledge, researchers have not measured communication at a behavioral level (i.e., between team members during actual play) or related such measures to team performance (Carron & Hausenblas, 1998). A multipurpose instrument is needed to evaluate the association between these behaviors and team functioning (Bowers, Jentsch, Salas, & Braun, 1998). Recent theoretical and practical advances in linking overt communication and team functioning clarifies this association through sequential analysis (Bowers et al., 1998) using advanced software such as the Discussion Analysis Tool (DAT; Jeong, 2003). We attempted to develop a new method to measure and directly relate intrateam communication to team performance.

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Existing Research on Team Communication

Team members (e.g., in sports, emergency response, and military operations) communicate to mediate team performance (Fiore, Salas, Cuevas, & Bowers, 2003; Salas & Cannon-Bowers, 2000), yet little is known about team communication (Guerlain, Shin, Guo, Adams, & Calland, 2002). Communication influences team processes, motivation, concentration, strategy, skill acquisition, attitudes, feelings, and behavior (Yukelson, 1993). Thus, insights into team communication would shed light on team performance and processes.

Previous research on team communication examined airplane crews sharing information during ongoing operations within a dynamic, externally paced, and uncertain environment. The findings were diverse and somewhat ambiguous. Several studies (Foushee & Manos, 1981; Mosier & Chidester, 1991; Orasanu, 1990) showed that aircrews in simulated airplane scenarios exhibited more explicit communication than other teams. Conversely, Jentsch, Sellin-Wolters, Bowers, and Salas (1995) noted that such research only moderately validated the assertion that more explicit communication is correlated with better performance. Thornton (1992) reported that the number of situational awareness statements (i.e., view of positioning in relation to the field) was positively correlated with the incidence of committed errors.

Eccles and Tenenbaum (2004, 2007) proposed that unstructured tasks seem to profit from more communication. This is likely because unstructured tasks involve more decision making and coordination of team labor (Toquam, Macaulay, Westra, Fujita, & Murphy, 1997).

Patterns of communication sequences have been shown to differ between more effective and less effective crews (Kanki, Folk, & Irwin, 1991; Kanki, Lozito, & Foushee, 1989; Kanki & Palmer, 1993). In particular, weaker performing teams exhibited little regularity in communication sequences (Kanki et al., 1989; Kanki & Palmer, 1993).

We selected tennis for our study, because it involves loosely structured tasks (e.g., multiple alternatives on how to play a point) and requires a considerable amount of decision making. In doubles tennis, team members must communicate effectively to solve problems and make decisions between and, to a lesser extent, within points.

Our study investigated communication patterns that discern more effective from less effective teams and the differences in communication patterns preceding winning versus losing points. We examined: (a) communication behaviors of effective teams, (b) effective processes that affect communication training procedures, (c) comparative frequencies of types of communication during single and dual communications between team members, (d) whether more effective teams would exhibit more nonverbal communication, and (e) a new statistical and graphical tool that may be used in analyzing communication in sports.

Method

Participants

Ten women between 19 and 23 years of age (M = 21.20 years, SD = 1.23) from a National Collegiate Athletic Association (NCAA) Division I women's tennis team at a large southeastern U.S. university participated in our study. Two participants had individual NCAA rankings (34th and 49th), and the college team as a whole was ranked 27th at the NCAA level. The team competed against other universities throughout the spring semester (i.e., dual match season). In the fall, however, the players competed in doubles and singles matches in common single-elimination tournaments. The rules of the dual matches stipulate that three doubles matches precede six singles matches. Some players played exclusively in doubles, and others exclusively in singles matches. The majority of the participants competed in both singles and doubles matches. By the end of the 9-month collegiate competitive season, when the study was performed, participants in the sample had practiced doubles tennis with one another during this time.

Procedure

This research was approved by the local Institutional Review Board. Participants read the research instructions and consented to participate in this investigation. The study involved doubles teams playing matches. The participants were assigned by the team head coach to experiment with new teams for the next season. The coach assigned players in pairs to form five doubles teams that would be similarly matched in terms of members' doubles tennis skills and the experience of playing together. Team 1 played Team 2, and Team 3 played Team 4. Subsequently, as there were only 10 players, another team needed to be formed. One participant from Team 2 and one from Team 4 formed Team 6, which played Team 5.

Matches were pro-sets, a convention within NCAA Division I tennis, in which the winning team is the first to score eight games with a difference of two; a tie-break is played if the score is 8-8. Pro-sets are between 8 (i.e., the score is 8-0) and 17 games (i.e., the score is 9-8, in which the winner is determined by a tie break). During each match, Teams 1 through 5 only were videotaped to capture their verbal and nonverbal communication. Team 6 lost the match with Team 5, so the communication series consisted of three winning teams and two losing teams.

Transcription

After each match, we transcribed each team's communication using the match video of that team. The members of the respective team were present during the transcription process to clarify any unclear communication. Communication that occurred within points was rare and between games was difficult to capture given the limits of the available recording equipment. Thus, only communication that occurred during each break between points was transcribed. Any communication that occurred during a given break was termed a communication unit. For example, Player 1 said, "Watch the wide serve," and Player 2 replied, "OK." Each communication unit was parsed into statements, defined as discrete sentences or phrases spoken by a team member (Jeong, 2003). The aggregate of each team's communication units was termed a communication series. For each communication series, information about the current match status was recorded, including the current score and whether the team won or lost the point.

Coding

Each message within each communication unit was coded once only as a type of statement according to a communication typology modified from Bowers et al. (1998), which contained six types. The typology, with a quote exemplifying each type, is specified in Table 1. The phrase "Watch for the wide serve" would be coded using the adopted typology an as action statement (ACT) and "OK" as an acknowledgement statement (ACK). Emotional statements (EMOs) could also include nonverbal components, such as a slap on the back. We conducted an interrater reliability assessment for the coding by randomly selecting the communication transcript for one team and having two other researchers code it. Interrater agreement was 95.1% and Cohen's kappa .88. Kappa values between .81 and 1 indicate "almost perfect" agreement (Landis & Koch, 1977, p. 165).

Analysis

All of the winning teams' coded communication series were collapsed to form one "winning team" data set. The same was undertaken for the losing teams to form one "losing team" data set. For each of the two groups, we performed an analysis using the Discussion Analysis Tool (Jeong, 2003), a software program developed to facilitate the analysis and visualization of discourse patterns in human communications. First, statement type frequencies were coded and tabulated. Second, a sequential analysis was performed on the data to identify patterns in the discourse produced between tennis partners (Bakeman & Gottman, 1997; Bakeman & Quera, 1995). In this study, there were 36 (6×6) possible combinations of contiguous statement types, or statement pairs. The expected transitional probability was the probability that one type of statement would directly follow another statement type based on random chance alone. For example, because there were 6 possible statement types, the expected probability for each statement type was .167 (or 1 divided by 6). We based the observed transitional probabilities on the number of times each pair of contiguous statement pairs was observed in the data set. For example, if 40 of the 100 observed statements following statement type A were statement type B, the observed transitional probability between statement type A and B would be .40 (or 40 divided by 100).

We used sequential analysis to examine the simplest, first-order chains of communication. For example, if in-between-the-point dialogue consisted of an action statement (ACT), then an acknowledgement statement (ACK), and finally another ACK statement, the communication pairs of the dialogue were as follows: ACT → ACK, and ACK → ACK. Although this example ends with an acknowledgement statement, it is unlikely for the first statement in a pattern to be the same as the last statement in the pattern preceding it.

To determine which observed transitional probabilities could be deemed as a "pattern" in the communications exchanged between the doubles partners, we computed *z* scores with the DAT software to determine whether each observed transitional probability was significantly higher or significantly lower than the expected

Table 1. Communication typology used for coding

Code category	Example quote
Uncertainty statement	Composed of direct and indirect questions (e.g., "Do you want me to return crosscourt?")
Action statement	Statement expressing preferred course of action or plan (e.g., "Place a slice serve into her body.")
Acknowledgement	Statement and/or short response following uncertainty or action statements (e.g., "Yes" or "Ok.")
Factual statement	Statement that verbalizes readily observable realities (e.g., "The wind is horrible") or statement relating to events or circumstances based on personal or team experiences (e.g., "I played against her last season and she struggled with volleys.")
Nontask statement	Statement not related to team task (e.g., "I need to change my shirt.")
Emotional statement	Statement expressing sentiment, mood, or reaction (e.g., "I feel anxious") or motivation offering inspiration, drive, or creating impulse on teammate (e.g., "Come on, you can do it!"), which could also include a nonverbal component such as slap on the back.

probability tested at alpha $p < .05$ (Bakeman & Gottman, 1997). We recorded both sets of data (i.e., for winning and losing teams) in separate documents within the DAT software, and separate frequency, transitional probability, and z score matrices were produced from the analysis of each data set. In addition, Fisher's exact two-tailed test was used to reveal if winning teams had a higher frequency of nonverbal communication than losing teams, and to test for differences between the transitional probability matrices of the winning teams versus the transitional probability matrix of the losing teams.

Results

Differences Between Winning and Losing Teams

The total number of patterns for the three winning teams observed in three matches was 243, with a mean of 81 patterns per match. The total number of patterns for the two losing teams during two matches was 84, with a mean of 42 messages per match. The number of points played in a match was identical for the winning and the losing teams; hence, the opportunity for communication was equal. Yet, the winning teams communicated twice as much as the losing teams.

Figure 1 shows the flow of communication for winning and losing teams. DAT software generated probabilities of communication channels as graphical pictures of communication events. In the diagram, thick lines indicate interactions that had a significantly higher probability of occurrence; thinner or dotted lines represent interactions that were less likely to occur.

Statistical analysis, including z scores for winning and losing teams, generated 11 patterns that had a significantly higher frequency of occurrence than expected. For winning teams, the expected frequency of occurrence was 6.75 per pattern. For losing teams, the expected value was 2.33 per pattern. These two values were obtained by dividing the total number of patterns by the number of all possible patterns (i.e., 36). While expected patterns are based on the assumption that communication sequences have an equal chance to occur, this assumption does not consist of practical and observable sequence occurrences and established base rates.

Among the 11 communication patterns that occurred within the five observed doubles matches (including three sets of winning teams and two sets of losing teams), 4 patterns included an ACT statement as a response to (a) an ACT, (b) an ACK, (c) a factual statement (FAC), and (d) an EMO. In addition, three patterns included an EMO as an initiating statement or as a response to an uncertainty statement (UNC), (b) a FAC, and (c) another EMO. Two patterns included an ACK as a response to (a) an UNC and (b) an ACT. The final groups of patterns included a FAC following (a) a FAC and (b) a nontask statement (NTS) followed by another NTS.

Major Differences. Visual inspection of communication diagrams for winning and losing teams shows that winning teams had a strong tendency for using ACT → ACT (e.g., "I'll be moving back and anticipating lobs" → "Wide fake" meaning "I'll serve wide and you make a fake move at the net"), UNC → ACK (e.g., "Do you want to serve?" → "Yes"), and FAC → ACT (e.g., "You were there" → "Kick it [the serve] out wide") patterns. By contrast, losing teams were characterized by an NTS → NTS pattern (e.g., "This [shoe] is driving me crazy" → "It does it to my heels too."). The observed probability and frequency statistics for initiating and subsequent statements (i.e., communication patterns) for winning and losing teams are shown

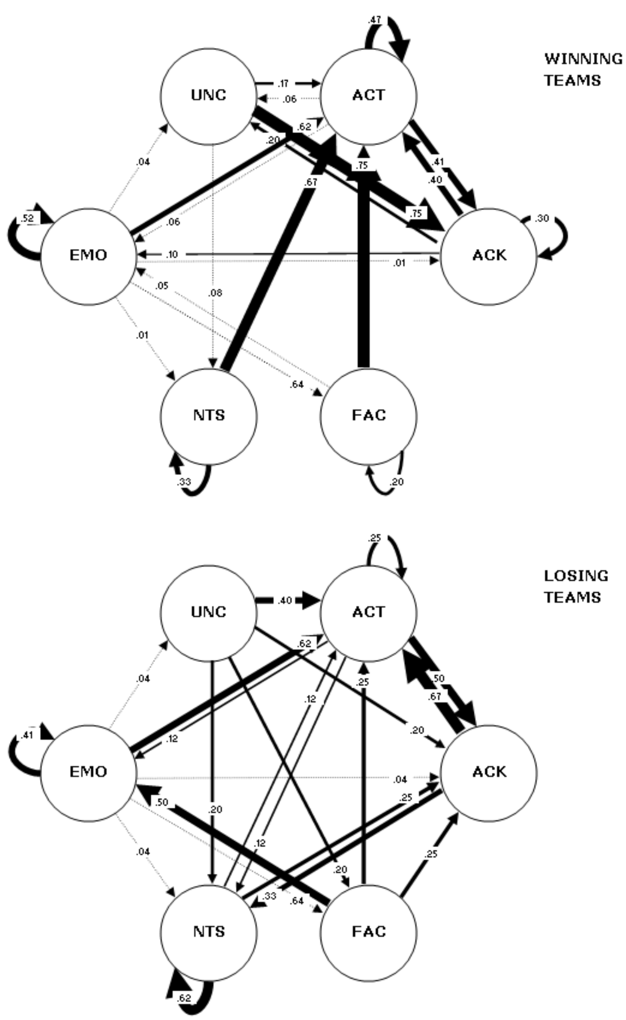

Figure 1. Communication event diagram for winning and losing teams. Circles depict different events, and arrows represent transitional probabilities between communication events; UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement.

in Table 2. Table 3 displays *z* scores and corresponding p values. In Table 3, the higher *z* scores indicate a higher probability of pattern occurrence.

Secondary Differences. Further inspection of communication diagrams for winning and losing teams reveals that both used an equal quantity of communication patterns. Namely, out of 36 possible patterns, winning teams used 21 communication patterns, and losing teams used 22. However, the teams differed in pattern style. Visual comparison of the two diagrams in Figure 1 shows that the communication patterns of the winning teams were more homogeneous (i.e., higher probability of certain patterns) than the patterns of the losing teams.

The statistical analysis revealed that out of 11 major communication patterns, winning teams used a total of 10 patterns: (a) ACT → ACT, (b) ACK → ACT, (c) FAC → ACT, (d) EMO → ACT, (e) EMO → UNC, (f) EMO →FAC, (g) EMO → EMO, (h) UNC → ACK, (i) ACT → ACK, and (j) FAC → FAC. These patterns occurred at probabilities higher than chance. Conversely, the losing teams were most likely to use only four patterns. While winning teams lacked only the NTS → NTS pattern, the losing teams lacked: (a) ACT → ACT, (b) ACK → ACT, (c) FAC → ACT, (d) EMO → UNC, (e) EMO → FAC, (f) UNC → ACK, and (g) FAC → FAC. Fisher's two-tailed exact test revealed no evidence to conclude that winning teams differed from losing teams in using nonverbal communication [χ^2 (1, N = 654) = .049, p = .824].

Table 2. Communication statements' frequencies and their percentages

Category name	Winning teams Freq.	%	Losing Teams Freq.	%	Totals Freq.	%
Uncertainty	12	2.6	7	3.7	19	2.9
Action	121	25.9	54	8.9	175	26.8
Acknowledgement	22	4.7	11	5.9	33	5.0
Factual	29	6.2	8	4.3	37	5.7
Nontask	3	0.6	11	5.9	14	2.1
Emotional	280	60.0	96	51.3	376	57.5
Totals	467	100.0	187	100.0	654	100.0
Emotional nonverbal	168	36.0	67	36.0	235	36.0
Emotional verbal	112	24.0	29	15.3	141	21.5

Note. Freq. = frequencies.

Differences in Communication Preceding Winning and Losing Outcomes

A total of 172 communication patterns resulted in a winning outcome and 155 patterns resulting in a losing outcome. Figure 2 shows patterns that occurred prior to winning points and prior to losing points. Visual inspection of these diagrams, *z* scores, and frequency counts indicate that only two patterns preceding winning out-

Table 3. Transitional probabilities and frequencies of communication patterns for winning and losing teams

Initiating statements	UNC %/freq.	ACT %/freq.	ACK %/freq.	FAC %/freq.	NTS %/freq.	EMO %/freq.	Total %/freq.
Winning team							
UNC	.00/0	.17/2	**.75/9**	.00/0	.08/1	.00/0	100/12
ACT	.06/1	**.47/8**	**.41/7**	.00/0	.00/0	.06/1	100/17
ACK	.20/2	**.40/4**	.30/3	.00/0	.00/0	.10/1	100/10
FAC	.00/0	**.75/15**	.00/0	**.20/4**	.00/0	.05/1	100/20
NTS	.00/0	.67/2	.00/0	.00/0	.33/1	.00/0	100/3
EMO	**.04/7**	**.33/59**	.01/2	**.09/17**	.01/1	**.52/95**	100/181
Total	10	90	21	21	3	98	243
Losing team							
UNC	.00/0	.40/2	.20/1	.20/1	.20/1	.00/0	100/5
ACT	.00/0	.25/2	**.50/4**	.00/0	.13/1	.13/1	100/8
ACK	.00/0	.67/2	.00/0	.00/0	.33/1	.00/0	100/3
FAC	.00/0	.25/1	.25/1	.00/0	.00/0	.50/2	100/4
NTS	.00/0	.13/1	.25/2	.00/0	**.63/5**	.00/0	100/8
EMO	.04/2	**.43/24**	.04/2	.05/3	.04/2	**.41/23**	100/56
Total	2	32	10	4	10	26	84

Note. UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement; %/freq. = percentages of frequencies; values in bold are higher than expected probability (*z* score < 1.96, alpha < .05) by statistical analysis.

comes are statistically significant: (a) ACT → ACK and (b) EMO → EMO. Similarly, only three significant patterns preceding losing outcomes: (a) ACT → ACK, (b) EMO → EMO, and (c) UNC → ACK.

Frequencies of Communications

We observed and coded 654 messages. The frequencies of each of the communication types are presented in Table 4. EMO statements, such as "Come on!" or "Great volley!" represented over a half of the messages (57.5%) communicated between team members. This was the only category that included verbal and nonverbal messages. ACT statements (26.8%), such as "I'll be moving back and anticipate lobs," ranked second most used. UNC, ACK, FAC, and NTS statements accounted for smaller percentages.

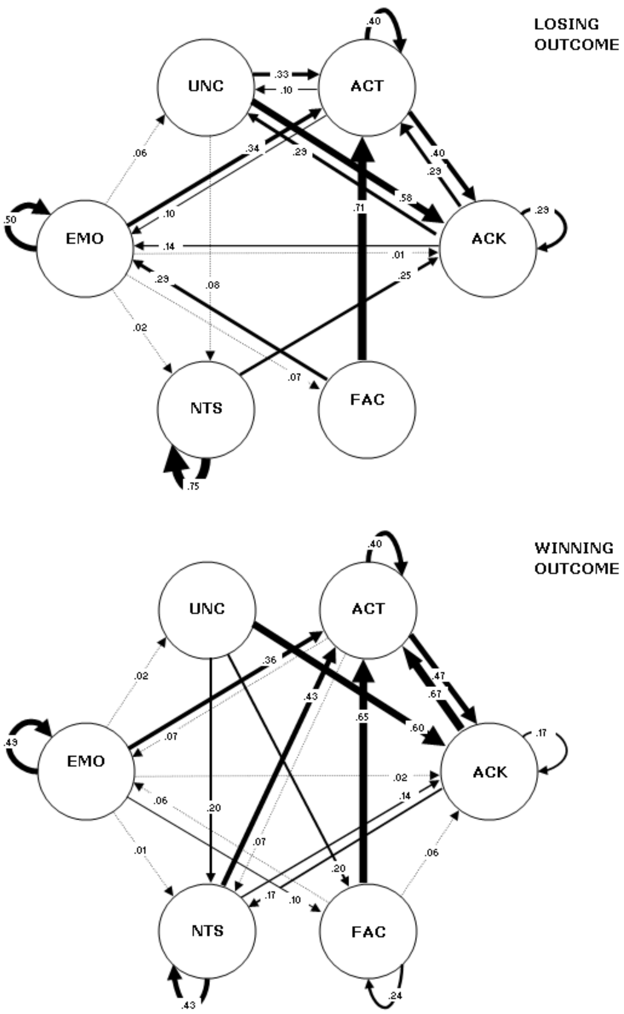

Figure 2. Communication event diagram for winning and losing outcomes. Circles depict different events, and arrows represent transitional probabilities between communication events; UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement.

Table 4. *Z* scores and probabilities of communication patterns in winning and losing teams

Initiating statement	Subsequent statement: Winning teams		Losing teams	
	z	*p*	*z*	*p*
UNC				
→ UNC	-0.40	0.69	0.00	1.00
→ ACT	0.42	0.67	2.39	0.02
→ ACK	8.89	0.00	0.82	0.41
→ FAC	-0.46	0.65	4.00	0.00
→ NTS	2.95	0.00	0.82	0.41
→ EMO	-0.40	0.69	-0.44	0.66
ACT				
→ UNC	1.80	0.07	0.00	1.00
→ ACT	4.40	0.00	1.57	0.12
→ ACK	5.31	0.00	4.10	0.00
→ FAC	-0.55	0.58	-0.33	0.74
→ NTS	-0.39	0.70	0.30	0.76
→ EMO	1.80	0.07	1.43	0.15
ACK				
→ UNC	5.49	0.00	0.00	1.00
→ ACT	2.64	0.01	3.43	0.00
→ ACK	2.67	0.01	-0.57	0.57
→ FAC	-0.42	0.67	-0.19	0.85
→ NTS	-0.29	0.77	1.43	0.15
→ EMO	2.56	0.01	-0.34	0.73
FAC				
→ UNC	-0.52	0.60	0.00	1.00
→ ACT	8.71	0.00	1.08	0.28
→ ACK	-1.36	0.17	1.08	0.28
→ FAC	6.73	0.00	-0.22	0.83
→ NTS	-0.43	0.67	-0.66	0.51
→ EMO	1.59	0.11	5.13	0.00
NTS				
→ UNC	-0.19	0.85	0.00	1.00
→ ACT	2.82	0.00	0.30	0.00
→ ACK	-0.51	0.61	1.57	0.61
→ FAC	-0.23	0.82	-0.33	0.74
→ NTS	6.27	0.00	5.37	0.00
→ EMO	-0.19	0.85	-0.57	0.57
EMO				
→ UNC	6.35	0.00	0.00	1.00
→ ACT	15.84	0.00	14.72	0.00
→ ACK	-6.66	0.00	-2.63	0.01
→ FAC	16.21	0.00	4.98	0.00
→ NTS	-0.80	0.42	-2.63	0.01
→ EMO	123.62	0.00	26.19	0.00

Note: UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement; (*z* score < 1.96, alpha < .05)

Discussion

Differences Between Winning and Losing Teams

Our study revealed that winning teams exchanged messages more frequently than losing teams, which is congruent with Orasanu's (1990), Foushee and Manos's (1981), and Mosier and Chidester's (1991) findings in nonsport domains. Moreover, patterns discerned more effective and less effective teams. In particular, while winning teams demonstrated a strong tendency for using UNC → ACK, ACT → ACT, and FAC → ACT patterns, losing teams made greater use of the NTS → NTS pattern.

These findings have several implications. When the UNC → ACK pattern is established and used, problem-solving stops, and further communication takes place. If the message receiver continues with problem solving without recognizing the UNC statement, the sender may or may not continue to use her current plan of action. Thus, the situation can ultimately lead to confusion, because the relevant knowledge was not shared between the partners about the upcoming plan of action (Eccles & Tenenbaum, 2004). Furthermore, winning teams had more significant communication patterns containing ACT statements (see Table 3) as they discussed actions and planned future events more frequently than losing teams, especially via ACT → ACT patterns. This pattern probably helped achieve shared knowledge about upcoming actions, which led to greater coordination, and in turn enhanced performance (Eccles & Tenenbaum 2004). In particular, winning teams had twice as many patterns ending with ACT statements in comparison to losing teams. These findings are congruent with results of Bowers et al.'s (1998) study of aircrew communication, where better performing teams used UNC → ACK patterns more often and had more patterns ending with ACT statements.

Winning teams used statements about readily observable realities and past team experiences via FAC → ACT patterns more frequently than losing teams. We speculated that winning teams could be more attuned to court conditions, such as wind and speed of the court surface, and were able to communicate experiences that facilitated better problem solving (i.e., a FAC statement such as "I played against her last season and she struggled with the volleys" could result in a shared plan to force the particular opposing player to hit more volleys). Information about certain environmental conditions can be used for strategizing and determining future actions. Winning teams lacked the NTS → NTS pattern characteristic of less effective teams. Because this pattern is not related to task solving, it appears valueless for achieving coordination and ultimately problem solving.

Despite the fact that both winning and losing teams used approximately the same number of communication patterns (i.e., 22 vs. 21, respectively), the winning teams emerged with 10 significant communication patterns. In contrast, the losing teams had only four statistically significant communication patterns. A small number of communication patterns may indicate a limited capability to coordinate actions and solve problems "on the fly," such as those encountered in tennis doubles. In particular, winning teams had more patterns including ACK statements (i.e., three vs. one) than losing teams. ACK statements "…provide the sender with a feedback that a message has been received and understood" (Bowers et al., 1998; p. 676) and thus affect task performance (Schmidt & Lee, 2005). A low capacity for communicating and solving problems may eventually lead to a losing outcome.

Further inspection of the bird's-eye diagram (see Figure 1) confirmed that the losing teams had a less homogenous message exchange. The fact that losing teams are marked with a heterogeneous overall communication pattern supports Kanki, Lozito, and Foushee's (1989) study of aircrew communications. They found that poorer performing crews had more speech variations, while better performing crews were marked by high rates of predictable patterns including observation statements, commands, and acknowledgements. Consistency in message exchange may provide an advantage to both team members. We speculate that this advantage was the partner's predictable behavior. With a rise in predictability, shared expectations increase, and the coordination of both team members is most likely to be successful in problem solving (Eccles & Tenenbaum, 2004, 2007).

Differences in Communication Preceding Winning and Losing Outcomes

With all communication patterns analyzed, the results suggest that there was virtually no difference between communication patterns preceding winning versus losing outcomes across winning/losing matches. This finding leads us to conclude that losing teams were focusing on skill execution (e.g., stroking the ball), whereas winning teams were focusing more on achieving a shared knowledge through increased communication of plans for action during upcoming points to enhance the coordination of their actions during play. Experimental evidence indicates that members of better performing teams were more likely to acknowledge questions from team members, therefore increasing communication and chance for coordination on tasks at hand (Bowers et al., 1998). Future research may determine whether experts and novice tennis doubles partners communicate differently prior to losing or winning points.

The study quantified the use of 11 significant communication patterns. Participants mostly used communication patterns linked to ACT statements, EMO statements, ACK statements, and NTS statements. Four types of patterns — ACT → ACT, ACK → ACT, FAC →

ACT, and EMO → ACT — contained ACT statements as a response. Three types of patterns consisted of EMO statement initiation (i.e., EMO → UNC, EMO → FAC, and EMO → EMO; see Tables 5 and 6).

During a typical tennis match, the content and other characteristics of message exchange can greatly affect the message receiver. As a successful team emerges, its players become proficient in exchanging a large number of positive, motivational messages that have an emotional component. It is reasonable to expect many communication patterns that contain emotional messages. Furthermore, following EMO statements, players were most likely to respond with another EMO statement (i.e., more than half of the time) or with an ACT statement (i.e., one third of the time). The receiver offers empathy and concern by responding emotionally, or decides to offer helpful advice for planning an action that would result in effective task solving. Last, two patterns included an ACK statement as a response (i.e., UNC → ACK and ACT → ACK). As the outcome of the following point might depend on an acknowledgement of the sent message, it is important to the sender that the recipient accepts and interprets the transmitted message. This is a vital condition for enhanced coordination in effective problem solving (Foushee & Manos, 1981).

This study had several limitations. First, the small sample size limited the power and scope of the study. In addition, we did not obtain the data during more salient competitions. Another limitation of the study was that it yielded a low count (one) of during-the-point communications (e.g., during a lob, the player can say "Yours" or "Switch," and her partner may say "Mine"). In addition, the data set included only 654 messages. As a result, the observed frequencies were small owing to a reasonably large number of potential communication pairs. Therefore, a larger set of communication messages achieved by using a larger sample of players is needed to generalize the findings.

This study is limited to first-order communication chains, rather than second- or third-order chains, which are more likely to resemble dialogues. Focusing on higher order chains, or sequences, of communication can clarify the role of communication in effective teams. Higher order chains should be taken into consideration in communication-performance linkage studies. Also, in the absence of base-rate data on communication patterns, it was assumed that all pairs have an equal probability of occurrence. More extensive research is needed to establish base-rate data so that more representative base rates can be used for inferential statistics.

Previous studies demonstrated that communication patterns, and to some extent communication counts, can distinguish more effective and less effective teams (Foushee & Manos, 1991; Kanki, Lozito, & Foushee, 1989; Mosier & Chidester, 1991; Orasanu, 1990). Future research needs to focus on supplementary conditions where communication occurs during message exchange, such as the type of task (i.e., serving vs. receiving). Also,

Table 5. Transitional probabilities and frequencies of communication patterns for winning and losing outcomes

Initiating statement	Subsequent statements UNC %/freq.	ACT %/freq.	ACK %/freq.	FAC %/freq.	NTS %/freq.	EMO %/freq.	Total %/freq.
Winning outcomes							
UNC	.00/0	.00/0	.60/3	.20/1	.20/1	.00/0	100/5
ACT	.00/0	.40/6	.47/7	.00/0	.07/1	.07/1	100/15
ACK	.00/0	.67/4	.17/1	.00/0	.17/1	.00/0	100/6
FAC	.00/0	.65/11	.06/1	.24/4	.00/0	.06/1	100/17
NTS	.00/0	.43/3	.14/1	.00/0	.43/3	.00/0	100/7
EMO	.02/2	.36/44	.02/3	.10/12	.01/1	.49/60	100/122
Total	2	68	16	17	7	62	172
Losing outcomes							
UNC	.00/0	.33/4	.58/7	.00/0	.08/1	.00/0	100/12
ACT	.10/1	.40/4	.40/4	.00/0	.00/0	.10/1	100/10
ACK	.29/2	.29/2	.29/2	.00/0	.00/0	.14/1	100/7
FAC	.00/0	.71/5	.00/0	.00/0	.00/0	.29/2	100/7
NTS	.00/0	.00/0	.25/1	.00/0	.75/3	.00/0	100/4
EMO	.06/7	.34/39	.01/1	.07/8	.02/2	.50/58	100/115
Total	10	54	15	8	6	62	155

Note. UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement; %/freq. = percentage of frequencies; values in bold = higher than expected probability (z score < 1.96, alpha < .05) by statistical analysis.

using within-participant designs may shed more light on whether certain patterns of communication contribute to enhanced coordination and effectiveness.

Table 6. *Z* scores and probabilities of communication patterns in winning and losing outcomes

Initiating statement	Subsequent statement: Winning outcome		Losing outcome	
	z	*p*	*z*	*p*
UNC				
→ UNC	-0.25	0.80	-0.95	0.34
→ ACT	-1.83	0.07	-0.11	0.91
→ ACK	3.96	0.00	5.94	0.00
→ FAC	0.77	0.44	-0.84	0.40
→ NTS	1.83	0.07	0.83	0.41
→ EMO	-1.70	0.09	-2.94	0.00
ACT				
→ UNC	-0.44	0.66	0.47	0.64
→ ACT	0.04	0.97	0.35	0.73
→ ACK	5.21	0.00	3.35	0.00
→ FAC	-1.34	0.18	-0.76	0.45
→ NTS	0.53	0.60	-0.66	0.51
→ EMO	-2.48	0.01	-2.00	0.05
ACK				
→ UNC	-0.27	0.79	2.44	0.01
→ ACT	1.38	0.17	-0.36	0.72
→ ACK	0.63	0.53	1.73	0.08
→ FAC	-0.83	0.41	-0.63	0.53
→ NTS	1.59	0.11	-0.54	0.59
→ EMO	-1.87	0.06	-1.42	0.16
FAC				
→ UNC	-0.47	0.64	-0.71	0.48
→ ACT	2.24	0.03	2.08	0.04
→ ACK	-0.51	0.61	-0.89	0.37
→ FAC	1.99	0.05	-0.63	0.53
→ NTS	-0.89	0.37	-0.54	0.61
→ EMO	-2.73	0.01	-0.63	0.53
NTS				
→ UNC	-0.29	0.77	-0.53	0.60
→ ACT	0.18	0.86	-1.48	0.14
→ ACK	0.46	0.65	1.05	0.29
→ FAC	-0.89	0.37	-0.47	0.64
→ NTS	5.30	0.00	7.47	0.00
→ EMO	-2.03	0.04	-1.65	0.10
EMO				
→ UNC	0.91	0.36	-0.31	0.76
→ ACT	-1.45	0.15	-0.41	0.68
→ ACK	-4.83	0.00	-6.29	0.00
→ FAC	-0.03	0.98	1.71	0.09
→ NTS	-3.37	0.00	-2.33	0.02
→ EMO	5.60	0.00	4.50	0.00

Note. UNC = uncertainty statement; ACT = action statement; ACK = acknowledgement statement; FAC = factual statement; NTS = nontask statement; EMO = emotional statement; (*z* score < 1.96, alpha < .05).

Future research also can investigate whether early/late use of certain types of communication messages contributes to successful outcomes. For example, a higher than expected use of ACT statements at the beginning of the match would indicate that teams are making early attempts to solve problems. Because a large proportion of human communication is nonverbal (Martens, 1987; Mehrabian, 1968), further exploration of the message exchange process in teams is needed. Implicit communication via body language, tone of voice, or speed of speech also can be examined. Nonverbal cues are likely to be more prominent when they oppose verbal messages (Burgoon, 1985; Burgoon, Buller, & Woodall, 1996). Thus, the full complete representation of message exchange is needed to enhance our knowledge of the team communication-coordination phenomenon.

The plausibility of explanations in this study can be tested by additional experimentation. Further understanding of problem solving via message exchange might be achieved by analyzing multiple-statement (i.e., three or more) patterns of communication. Software with a capability of analyzing several sequences in a problem-solving event, such as DAT, can be used for data analysis. Finally, future research can determine whether our findings apply to professional and recreational tennis teams and other team sports, as well as other settings in which communication is vital to coordination.

References

Bakeman, R., & Gottman, J. (1997). *Observing interaction: An introduction to sequential analysis.* Cambridge, UK: Cambridge University Press.

Bakeman, R., & Quera, V. (1995). *Analyzing interaction: Sequential analysis with SDIS and GSEQ.* Cambridge, UK: Cambridge University Press.

Bowers, C., Jentsch, F., Salas, E., & Braun, C. C. (1998). Analyzing communication sequences for team training needs assessment. *Human Factors, 4,* 672–679

Burgoon, J. K. (1985). The relationship of verbal and nonverbal codes. In B. Dervin & M. J. Voight (Eds.), *Progress in communication sciences* (Vol. 6, pp. 263–298). Norwood, NJ: Ablex.

Burgoon, J. K., Buller, D. B., & Woodall, W. G. (1996). *Nonverbal communication: The unspoken dialogue.* New York: McGraw-Hill.

Carron, A. V., & Hausenblas, H. A. (1998). *Group dynamics in sport* (2nd ed.). Morgantown, WV: Fitness Information Technology.

Carron, A. V., & Spink, K. S. (1993). Team building in an exercise setting. *The Sport Psychologist, 7,* 8–18.

Eccles, D. W., & Johnson, M. B. (2007). Letting the social and cognitive merge: New concepts for an understanding of group functioning in sport. In S. Mellalieu & S. Hanton (Eds.), *Literature reviews in applied sport psychology* (pp. 281–315). London: Routledge.

Eccles, D. W., & Tenenbaum, G. (2004). Why an expert team is more than a team of experts: A social-cognitive conceptualization of team coordination and communication in sport. *Journal of Sport and Exercise Psychology, 26,* 542–560.

Eccles, D. W., & Tenenbaum, G. (2007). A social cognitive perspective on team functioning in sport. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of sport psychology* (3rd ed., pp. 264–283). New York: Wiley.

Fiore, S. M., Salas, E., Cuevas, H. M., & Bowers, C. A. (2003). Distributed coordination space: Toward a theory of distributed team process and performance. *Theoretical Issues in Ergonomic Science, 4*, 340–364.

Foushee, H. C., & Manos, K. (1981). Information transfer within the cockpit: Problems in intracockpit communications. In C. E. Billings & E. S. Cheaney (Eds.), *Information transfer problems in the aviation system* (Report No. NASA TP-1875). Moffett Field, CA: NASA-Ames Research Center.

Guerlain, S., Shin, T., Guo, H., Adams, R., & Calland, J. F. (2002). A team performance data collection and analysis system. *Proceedings of the Human Factors and Ergonomics Society 46th Annual Meeting* (pp. 1443–1447). Santa Monica, CA: Human Factors and Ergonomics Society.

Jentsch, F. G., Sellin-Wolters, S., Bowers, C. A., & Salas, E. (1995). Crew coordination behaviors as predictors of problem detection and decision making times. *Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting* (pp. 1350–1353). Santa Monica, CA: Human Factors and Ergonomics Society.

Jeong, A. (2003). The sequential analysis of group interaction and critical thinking in online threaded discussions. *The American Journal of Distance Education, 1*, 25–43.

Kanki, B. G., Folk, V. G., & Irwin, C. M. (1991). Communication variations and aircrew performance. *International Journal of Aviation Psychology, 1*, 149–162.

Kanki, B. G., Lozito, S.C., & Foushee, H. C. (1989). Communication indexes of crew coordination. *Aviation, Space, and Environmental Medicine, 60*, 56–60.

Kanki, B. G., & Palmer, M. T. (1993). Communication and crew resource management. In E. L. Weiner, B. G. Kanki, & R. L. Helmreich (Eds.), *Cockpit resource management* (pp. 99–136). San Diego, CA: Academic Press.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33,* 159 –174.

Martens, R. (1987). *Coaches guide to sport psychology*. Champaign, IL: Human Kinetics.

Mehrabian, A. (1968). Communication without words. *Psychology Today, 2*, 52–55.

Mosier, K. L., & Chidester, T. R. (1991). Situation assessment and situation awareness in a team setting. In Y. Quéinnec & F. Daniellou (Eds.), *Designing for everyone: Proceedings of the 11th Congress of the International Ergonomics Association* (pp. 798–800). London, UK: Taylor & Francis.

Orasanu, J. (1990). *Shared mental models and crew performance* (Report No. CSLTR-46). Princeton, NJ: Princeton University Press.

Salas, E., & Cannon-Bowers, J. A. (2000). The anatomy of team training. In S. Tobias & J. D. Fletcher (Eds.), *Training and retraining: A handbook for business, industry, government, and the military* (pp. 312–335). New York: Macmillan.

Schmidt, R. A., & Lee, T. D. (2005). *Motor control and learning: a behavioral emphasis* (4th ed.). Champaign, IL: Human Kinetics.

Sullivan, P. J., & Feltz, D. L. (2003). The preliminary development of the Scale for Effective Communication in Sport Teams (SECTS). *Journal of Applied Social Psychology, 33*, 1693–1715.

Thornton, R. C. (1992). *The effects of automation and task difficulty on crew coordination, workload, and performance*. Unpublished doctoral dissertation, Old Dominion University, Norfolk, VA.

Toquam, J. L., Macaulay, J. L., Westra, C. D., Fujita, Y., & Murphy, S. E. (1997). Assessment of nuclear power plant crew performance variability. In M. T. Brannick, E. Salas, & C. Prince (Eds.), *Team performance assessment and measurement: Theories, methods, and applications* (pp. 153–287). Mahwah, NJ: Erlbaum.

Yukelson, D. (1993). Communicating effectively. In J. M. Williams (Ed.), *Applied sport psychology: Personal growth to peak performance* (2nd ed., pp. 122–136). Mountain View, CA: Mayfield.

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