The Effects of Pre-task Team Collaboration on Facial Expression and Speech Entrainment

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Introduction. Many everyday tasks are complex and require the coordination of one or more individuals. Such tasks can be relatively simple like passing a ball to a friend during a game of catch, while others are more complex such as performing a life-saving surgery where surgeons, anesthesiologists and nurses all work together in a multi-person team [1]. Such coordination requires the appropriate allocation of cognitive and behavioral effort to meet the changing demands of their environment and cannot be completed alone [1]. These mutually cooperative behaviors can include team communication, body position and even affective cues [2]. Some behaviors are explicitly controlled to be coordinated [3] (e.g., when an individual purposely attempts to follow the behaviors of their teammate or team leader), while others are implicit or unconscious. Presently, these shared behaviors have been referred to as entrainment [4] [5], mimicry [6] [7] and even action matching [8] [9]; however, the specific term used typically refers to the underlying theoretical cause for the phenomenon. Theoretically, entrainment can be explained as the *spontaneous* interpersonal coupling that occurs because the behavior of one or more individuals is affected by another's behavior in a closed loop system. Additionally, such behavior is typically evident when working on a mutual, goal-directed task [10]. Therefore, for the purposes of this paper we will refer to the cooperative behaviors between teammates that support problem solving as entrainment.

The current study utilized multimodal analysis techniques to assess team entrainment during a high workload task. Several behaviors relating to team coordination were automatically assessed and included changes in nonverbal behavior such as facial expression and verbal features of inter-team communication. Our experimental manipulation involved allowing half of our participants to develop a level of familiarity with their teammate prior to participating in the task as a means for enhancing team coordination. We utilized nonlinear analysis techniques to get a more robust measure of the intricate and dynamic changes in team behavior, rather than static, averaged measures, which do not account for the natural fluctuation in real-time behavioral responses [11]. It is the assumption that giving individuals a chance to familiarize themselves with their teammates prior to engaging in a stressful, high-workload task will enhance team coordination and entrainment both during and after teammates are asked to switch roles mid-way through the experiment. The following will serve as our three main research questions for the current study:
Q1: Does pre-task inter-team familiarity impact team entrainment while performing a task?
Q2: Second, does entrainment differ among team members who are performing markedly dissimilar roles, which require fundamentally different cognitive and physical demands?
Q3: Lastly, does the level of entrainment prior to the teammates' role switch impact post-switch entrainment?

Methods. Twenty men and twenty women (N= 40) (ages 18-65; M = 40.03 years, SD = 13.39) participated in 2-person gender matched teams. Teams were not familiar with each other prior to participating and were randomly assigned to either the Icebreaker (IB) (N= 20) or Control (CT) (N= 20) conditions. This study employed a between-subjects design, with 1 experimental condition. The between-subjects factor included an experimental manipulation, which was an 'Ice Breaker Conversation' (IB) between teammates prior to the task as well as the 'Control' (CT) condition (i.e., no conversation/familiarity among team members prior to the task). Dependent variables included speech between participants and facial expressivity. The main task consisted of a simulated "bomb diffusion" scenario. In each scenario one team member served as the 'diffuser' and one team member served as the 'instructor'. The 'instructor' was given a manual with instructions on how to diffuse the bomb and was told that it was their responsibility to provide information that would allow the 'diffuser' to successfully complete the task. Each team was required to complete a series of 4bomb diffusion trials in succession. Additionally, after trial 2 the team members switched roles so that both team members would be able to participate in each role during the tasks.

Results. A 5 (facial entrainment features) x4 (trial) repeated measures ANOVA was run to determine if facial expressions among teammates changed over time, across trials and between groups. Results revealed that facial expressions did not significantly change across trials F, (3, 15) = 2.25, p > .05, partial eta^2= .31 or between groups F, (1, 17) = .260, p > .05, partial eta^2= .015. However, further inspection of the means revealed that the IB condition exhibited slightly higher levels of entrainment for each of the five entrainment measures across *most* trials.

Additionally, linear regressions were run to determine if the level of facial entrainment prior to the teammates' role switch (i.e., entrainment during trial 2) impacts post-role switch levels of entrainment (i.e., entrainment during trial 3). Results did indeed reveal that the level of entrainment for recurrence rate during trial 2 predicts the recurrence rate for trial 3 (i.e., the trial right after the role switch), $\beta = .845$, $t(19) = 3.29$, $p < .01$ (ΔR^2=.48). Additionally, the length of longest diagonal line during trial 2 predicts a significant amount of variance for averaged diagonal length for trial 3, $\beta = -.077$, $t(19) = -2.69$, $p < .01$ (ΔR^2=.51). Finally, it appears that the largest changes in facial expression entrainment occur from trial 2 to 3, which again reflects the time when teammates switch roles. Although not significant, some trends are evident. For example, for each facial entrainment feature, participants in the IB condition exhibit decreases in entrainment from trial 2 to 3; however, the opposite is true for participants in the CT condition. Here facial entrainment increases from trial 2 to 3.

A 14 (speech entrainment features) x4 (trial) repeated measures ANOVA was run to determine differences in speech entrainment over time and between groups. Results revealed no significant differences over time for the speech features F, (5, 13) = 1.38, $p > .05$, partial eta^2= .34, which indicates that the entrainment of speech used between teammates did not change across trials). Additionally, no group differences were found p = .474. Even though not statistically significant, further inspection of the means for the *mean cosine distance* feature revealed that the CT condition exhibited higher values, which indicates that this group exhibited more dissimilar speech usage. Further inspection of the *mean edit distance* feature revealed that participants in the IB condition exhibited higher distances in trial 4; however, the CT condition was higher in trial 2 and 3. The edit distance for Trial 1 was nearly equal between groups (M= 42.18 and M= 42.48 respectively). Additionally, it was of interest to explore whether any of the speech features related to or predicted performance outcomes. Performance was assessed via total number of modules diffused, which was then averaged across the four trials. Results revealed that the cosine and edit distance features did not predict subsequent performance, $p > .05$ for all trials; however the specific LIWC categories for *social words* negatively correlated with performance, r= -.521, while the LIWC word categories relating to *power* positively correlated with performance, r= .464, which indicates that these types of word categories relate to worse and better performance respectively. Analyses were conducted to determine if any relationship existed between entrainment and team performance, however no differences were found, $p > .05$ in all cases.

Discussion. The following main findings can be identified based on our three research questions. First, there are preliminary findings suggesting that pre-task team familiarity affects similarities within speech and facial expressions between teammates. In particular, the edit and cosine distance features were more similar within the IB condition. Additionally, the level of facial expression entrainment, although generally low across the entire sample, was somewhat higher within the IB condition, suggesting that synchronicity before a team task may enhance these entrainment features. Second, we also provide further support to the relatively few studies, which have assessed entrainment among teams when members perform dissimilar roles. Here, we found that levels of facial entrainment were relatively low across the entire sample, which may offer insight into team tasks where members perform different roles. Lastly, these findings suggest that a role switch may actually harm entrainment among teams in that high pre-role switch levels of entrainment significantly predict lower post-role switch entrainment. Additionally, it was found that the entrainment levels for the facial expression data were somewhat higher in the IB condition, compared to the CT during trial 2 (i.e., pre-task switch) but then reversed and was lower than the CT during trail 3 (i.e., post-role switch), which suggests that individuals who exhibit higher levels of facial entrainment may take longer to recover (i.e., get back to pre-role switch baselines) following a role switch than those who exhibit lower levels of entrainment.

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