Applied Ergonomics, Volume 95, September 2021, Article number 103459
DOI: 10.1016/j.apergo.2021.103459

Evaluating teamwork development in combat training settings: An exploratory cas e study utilising the Junior Leaders' Field Gun competition

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Highlights

- A teamwork assessment protocol was constructed.
- Teams undergoing combat training were assessed.
- Improvements in teamwork dimensions as a result of training were evident.
- The protocol developed may have applicability in further naturalistic settings.

Abstract

A behaviourally-anchored observational rating scale (BAORS) of teamwork based upon the 'Big Five' teamwork model (Salas et al., 2005) was selected and adapted for use in a combat training setting – a UK military field gun competition. The teamwork development of 16 newly-formed teams training to master a historic tactical drill was evaluated over the course of a week-long residential programme. Training culminated in a timed field gun competition. Teams were trained and mentored in respects to teamwork and taskwork by experienced military instructors. Teamwork was assessed at the outset and end of training. Significant improvements were evident on all teamwork process dimensions, with the greatest improvement seen in teams' shared understanding of teamwork roles and strategies (shared mental models). The lack of an association between teamwork development and final drill performance is explored, as is the utility of the measurement protocol developed for teamwork assessment in other settings.

Keywords: Applied teamwork measurement; Teamwork training; Military field gun combat exercise

1. Introduction

A team is accepted as comprising two or more individuals working towards a common goal with set roles and role interdependencies (Mathieu et al., 2017; Salas et al., 1995; Shuffler et al., 2012). Teams are not effective purely by combining the efforts of multiple people (McEwan et al., 2017; Salas et al., 2018). Rather, team efficiency is understood to be a multi-faceted, multi-level process, combining both taskwork with teamwork for beneficial effect (Humphrey et al., 2009; Salas et al., 2008). Whilst taskwork refers to the job-at-hand, teamwork focusses on the shared behaviours and cognition required to coordinate taskwork (Salas et al., 2015). Teams and teamwork features prominently in defence training guidance with teams being a key component of defence human capability at all operational levels (Ministry of Defence, 2019).

Another cornerstone of military capability is combat skill. Defence invests a great deal of resources in the training of combat skills, with all personnel requiring competence in this regard. Whilst assessment aligned to observable task performance outcomes is customary within combat training settings, assessment of the observable indicators of teamwork efficiency are underutilised. Issues concerning an appropriate means of operationalising and quantifying teamwork along with practical concerns about teamwork assessment within combat settings may be responsible for this omission. The present paper seeks to explore this gap in training appraisal by considering best practice in applied teamwork measurement before applying practical protocol for assessing teamwork development within a combat training case study. If suitable, the protocol developed might be leveraged for teamwork measurement in further combat settings.

1.1.Theoretical background

Salas et al.'s (2005) 'Big Five' teamwork model was identified as an appropriate theoretical basis for operationalising teamwork. The model depicted in Figure 1 proposes that teamwork is a product of five core teamwork dimensions: leadership, orientation, monitoring, back-up behaviour, and adaptability. *Leadership* moderates team effectiveness through the ability to set, reinforce or refine performance expectations. Leaders are responsible for directing the activities of team members, monitoring progress, workload assignment, promoting task skills, and motivating the team. Good leaders must be articulate and generate a positive team atmosphere. *Team orientation* reflects the willingness of team members to engage in pursuit of shared goals. This includes valuing the input of all team members. *Mutual performance monitoring* affects performance through the discussion of performance strategies and where appropriate, performance inefficiencies. *Back-up behaviour* involves the ability for team members to anticipate each other's needs and offer support wherever necessary. *Adaptability* involves suitable reallocation of team personnel and resources to respond to changing environmental conditions.

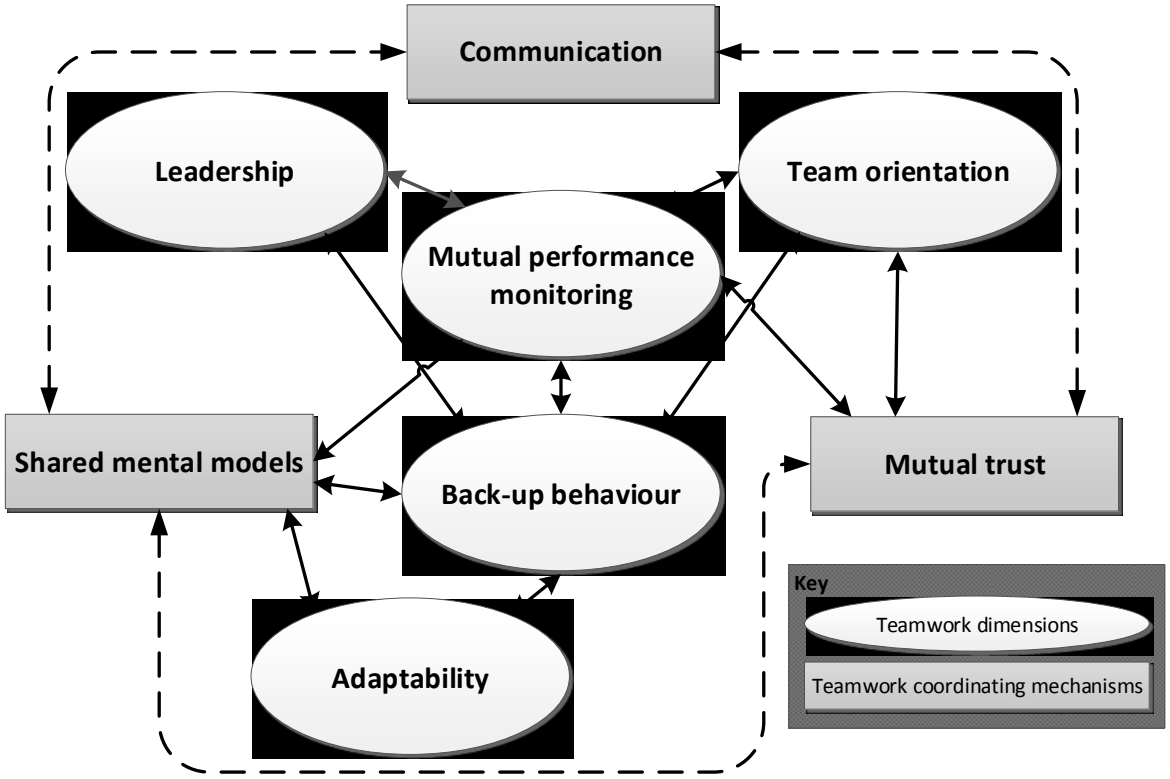

Figure 1: Salas et al.'s (2005) teamwork model

Salas et al. (2005) suggest that these dimensions are underpinned by three coordinating mechanisms that promote team efficiency. Firstly, clear, concise and accurate *Communication* facilitates team effectiveness by updating taskwork and teamwork strategies. More specifically, communication serves to improve critical processes such as coordination and strategy formulation as well as clarifying misunderstandings (Marlow et al., 2018; Salas et al., 2015, 2018). It is likely that communication is the building block upon which the majority of the five core dimensions of teamwork are developed. Secondly, *Shared mental models* reflect the team's collective understanding of team roles, task procedures, and team interaction strategies (Shuffler et al., 2012).

Enhanced *Shared mental models* require adequate information sharing alongside mechanisms for the clarification of key task strategies (Lavelle et al., 2020). Shared cognition, wherein team members can interpret changes in team task conditions, predict the requirements of teammates, and adapt accordingly is dependent upon the generation and communication of shared mental models (Salas et al., 2008; Salas et al., 2018). Finally, *Mutual trust* facilitates team effectiveness via consolidating teamwork dimensions such as teamwork orientation, mutual performance monitoring and back-up behaviours. Trust improves cooperation, reduces defensiveness, and prevents conflict (Grossman & Feitosa, 2018).

The explanatory power of the Big Five theoretical framework centres around the inclusion of interacting behavioural processes that clarify what is required of effective teams rather than merely focussing on desirable team inputs and beneficial task outputs (Svensson et al., 2020). Whilst the model exhibits significant conceptual overlap with other key teamwork models, for example Crew Resource Management from the aviation domain (e.g., Oransanu, 2010) and Non-Technical Skills for Surgeons (e.g., Jung et al., 2018), it possesses the added benefit of being applicable regardless of task- or context-specificity (Salas et al., 2015). Indeed, the onus on generic, transportable teamwork skills has resulted in the successful application of the Big Five model within a sample of military contexts including peacekeeping (Duel, 2010); fighter pilots (Ohlander et al., 2019) and command and control (Hussain et al., 2007; Webster et al., 2020). To the authors' knowledge there is scant evidence of the applicability of the model to the action teams required in combat domains. However, the physical nature of combat training can be benchmarked against sports teams for which there is evidence that the Big Five model is well-suited (e.g., Neville et al., 2016).

When promoting rigour in teamwork evaluation, there is a requirement for teamwork assessment to be derived from robust teamwork theory and specified at the level of specific behavioural indicators rather than high-level, 'abstract' ones (Marriage & Kinnear, 2016; Rosen et al., 2010). We propose that the Big Five model meets this criteria. It has been applied in a variety of relevant contexts and there is indication of its validity as a teamwork measurement tool. For instance, Duel (2010) reported that the model scores high on face validity and content reliability whilst Van Roosmalen (2012) reports statistical validation of the five core teamwork dimensions and three coordinating mechanisms. When considered alongside the availability of behavioural indicators aligned to the different teamwork dimensions, as compiled by Baker et al. (2005), the Big Five model represents a key starting point for the development of a teamwork measurement protocol within a combat training context.

1.2 Teamwork assessment

Whilst the Big Five teamwork framework represents a sound theoretical basis for operationalising teamwork, there are a number of choices to be made over how to apply and quantify teamwork measurement. The unit of analysis is a key consideration in teamwork assessment. As there are indications that team level analysis captures the dynamic nature of team interactions, team level analysis is preferable over individual team-member assessment (Goodwin et al., 2018; Mathieu et al., 2017). This offers a number of practical benefits over individual analysis in that it reduces the data collation burden, enables easier collection of teamwork data over time, and is likely to be less intrusive than other units of analysis (Salas et al., 2018). Selecting the team as the unit of analysis requires the availability of trained teamwork assessors with sufficient access to team activities (Marriage & Kinear, 2016). Whilst this may be impractical in many field contexts other than that of military training, defence training settings necessitate the presence of military instructors who have

access to team observation opportunities and play the additional dual role of trainee observer-mentors.

A further team assessment consideration concerns the measurement scale used. Scales can be broadly categorised into behaviourally-anchored rating scales (BARS), behaviour observation scales (BOS), or specific event-based critical incidents (Marriage & Kinnear, 2016; Rosen et al., 2010). BARS rate the acceptability of teamwork activity aligned to teamwork indicators, BOS rate the extent to which the relevant teamwork behaviours were observed, and critical incidents apply one of these measurements to a dynamic change in the teamwork environment. Critical incident analysis was considered unsuitable for present purposes. This was because combat training places considerable physical strain on the trainees and adding a critical incident would require an increased threat to individual safety that was eliminated on ethical grounds. BARS and BOS remain applicable to a combat training programme. Given the recommendation that teamwork be assessed over time (Salas et al., 2018), we assert that either scale alone would not be sufficient for present purposes. Indeed, as combat training is typically undertaken by newly formed teams, it is likely that some of the relevant teamwork indicators would not be observable in initial training stages. Other teamwork efficiency indicators might be both overtly evident and demonstrated to an adequate level from the onset of training should trainees be motivated to master training content. In order to best track and assess teamwork development over time, structured behaviourally-anchored observational rating scales (BAORS) would combine the merits of both approaches and present a better fit to combat training contexts.

1.3 Purpose and rationale

Team effectiveness will not automatically result from task-specific training. Teamwork training requires additional “instructional strategies and tools aimed at enhancing teamwork knowledge, skills, processes, and performance” (Tannenbaum et al., 1996, p516). At the passive end of the teamwork training spectrum sit didactic classroom strategies and demonstration. More active strategies where trainees are immersed in direct examination of teamwork processes include practice, simulation, and immersive teamwork reviews (Hughes et al., 2016; McEwan et al., 2017). Training programmes that incorporate multiple active learning elements are considered beneficial for instilling desirable team qualities such as agility and resilience (Salas et al., 2012, 2015). Across combat training settings, defence utilises a variety of teamwork training interventions, favouring the inclusion of active strategies such as practice coupled with interactive team reviews and coaching (both in-situ, and after action).

The purpose of the present piece of research is to trial a teamwork measurement protocol for use in combat settings. Defence seeks to standardise training performance criteria wherever possible in order to ensure that assessment methods are used consistently across its varied training programmes. The incidence of team level assessment within the training literature is somewhat sparse. Therefore, there is a need to consider the suitability of existing teamwork frameworks and measurement tools in order to develop context-specific teamwork assessment guidance (Salas et al., 2008, 2018). We propose that the existing behavioural teamwork indicators aligned to the Big Five teamwork model as reported by Baker et al. (2005), accompanied by BAORS represent a valuable basis for the generation of a teamwork measurement protocol. In order to test such a protocol, a case study is required.

1.4 Case study setting

Assessment of teams in naturalistic settings is challenging. A lack of control over environmental variables often lead to 'messy' designs and confounded results (Goodwin et al., 2018; Salas et al., 2018). Unsurprisingly, studying (team-level) teamwork development in combat training settings raises additional issues. Firstly, the sensitive nature of many combat training programmes raises security concerns that prevent research access. Secondly, there are practical difficulties in rolling out the coordinated training and assessment of multiple teams. Difficulties include the availability of competent teamwork raters, as well as the ability to create comparable task and environmental conditions in order to be able to collate team assessments for further analysis. Lastly, ethical guidance requires the informed consent of training participants. As maintaining competence in combat skills is a mandatory aspect of military professions, ensuring that participation is voluntary becomes crucial.

The Royal Navy's annual Junior Leaders' Field Gun (JLFG) competition represents a unique opportunity to avoid many of these issues. The JLFG event invites multiple newly-formed teams to immerse themselves into a week-long residential programme in order to learn a historic tactical field gun drill. Training culminates in an inter-team competition. The JLFG event incorporates teamwork training provision and mentorship. It is promoted as instilling core Naval values including teamwork. All involved are volunteers and the historic nature of the drill raises no security concerns. As such, the JLFG represents a suitable testbed for the application of a teamwork assessment protocol.

2. Method

2.1 JLFG event overview

The JLFG drill originates from the historical 1899 siege of Ladysmith during the Second Boer War wherein the Royal Navy landed and transported guns over difficult terrain to aid the hard-pressed British Army. This involved the construction of makeshift gun carriages and the circumventing of various obstacles along the route. Various iterations of field gun competitions have been held ever since.

At the outset of the five-day 2019 JLFG training programme, each team was assigned a number one (#1) and number two (#2) trainer. Exceptions were the teams comprised of Service personnel from the British Army, Royal Navy, and Royal Air Force, who arrived with trainers. All trainers were drawn from either former or active Service personnel, with trainer #1 required to have progressed into the position once they have successfully trained and mentored a junior field gun team as a #2 trainer. Many trainers had several years of JLFG experience and/or had themselves competed in a Field Gun contest. Each team was assigned three or four training slots (each an hour long) a day on Day 1, Day 2 and Day 3, and approximately three or four 30 minutes practice slots on Day 4 and 5. Training sessions were split across the various field gun tracks to acquaint teams with variations in surface conditions on the different tracks. A seventh track was available (subject to booking) for trainers seeking additional practice time for their teams. It is important to note, use of all scheduled and additional training slots were utilised at the discretion of the trainers and their assessment of team training vs. team rest requirements. Accumulative scheduled track training times per team totalled approximately 14.5 hours (see Table 1).

Table 1: Indicative team training and competition schedule

Time	Day 1	Day 2	Day 3	Day 4	Day 5
08.00		Track 4			Track 6
				Track 4	
09.00	Track 1		Track 6		
					Track 4
10.00				Track 2	
11.00		Track 6	Track 1		Track 1
				Track 5	
12.00	Track 5				Entrance ceremony
					Competition heat 2
13.00				Track 1	
					Competition heat 3
14.00		Track 3			
				Entrance ceremony	Tier 3 final
15.00	Track 2		Track 3		Tier 2 final
				Competition heat 1	Tier 1 Final
16.00					Closing ceremony
				Key	Training time slot
17.00		Track 2	Track 5		Competition time slot

Figure 2: The JLFG equipment (12 pound field gun and gun carriage with ammunition box)

Teams were familiarised with the field gun equipment (see Figure 2) on Day 1. At this point they began to run part-drills under the instruction of their #1 and #2 trainers. Within each team, roles were assigned based upon trainer perception of individual skill. It is worthwhile noting that whilst team sizes varied, completion of the drill required a minimum team size of 18 members. Sub-team roles were broken down into i) those focused on the build and transportation of the gun carriage, ii) roles focused on the ability to quickly drag and manoeuvre the heavy field gun, and iii) roles responsible for the rapid and precise loading and firing of field gun cartridges. By Day 3, teams progressed onto running full field gun drills. The present drill format simulates the following precision activities interspersed throughout a timed gun drill, performed on an 85 yard (77.72 metres) track:

- Gun carriage box build

- Gun carriage lift
- Gun carriage attachment to field gun
- Gun carriage unlimber
- Field gun positioning
- Action 1 (firing 3 shots)
- Gun carriage attachment to field gun
- Field gun and carriage halt
- Gun carriage unlimber
- Field gun positioning
- Action 2 (firing 3 shots)
- Gun carriage attachment to field gun
- Gun, gun carriage, and team to cross the finish line

Each team competed in three timed drill heats followed by a JLFG tiered final dependent upon performance in heats 1-3 (with the leaders going into the Tier 1 final, and other teams competing in the Tier 2 or 3 final). Guests were invited to spectate on Day 5, the day of the main competition, with teams, trainers, field gun staff, and guests present for the closing award ceremony.

2.1.1 Teamwork training

No formal, standardised teamwork training programme was delivered. Instead, trainers instructed and mentored the teams regarding the optimisation of the team tasks and the teamwork processes required in order to successfully coordinate and carry out the field gun drill. Trainers called upon their experience, judgement and discretion in order to tailor active teamwork training strategies to the team that they were mentoring, as is typical in military training environments. Various teamwork training strategies (e.g., Bisbey et al., 2019; Driskell et al., 2018; McEwan et al., 2017) that were employed by trainers throughout the training programme included, but were not limited to:

- The provision of qualified and experienced instructors, familiarised with the teamwork measurement tool
- Diagnostic feedback and support
- The reinforcement/recognition of teamwork training goals and gains
- Team briefs
- Timely after-action team reviews
- Equivalence (and therefore ease of transfer) between training and performance modes
- Ensuring adequate conditions for enacting successful teamwork

2.2 Participants

Data was available for sixteen teams who competed in the 2019 JLFG competition (see Table 2), including three Service teams comprised of junior military personnel. The 13 remaining teams were drawn from UK colleges (sixth forms, university technical colleges, and residential schools) and military cadet teams. All were volunteers. Whilst a minimum of 288 volunteers were required across the 16 teams to run the field gun drill, team membership across all volunteers amounted to 337 JLFG participants, with an average team size of 21. Participants ranged from 16 - 27 years of age, with an average age of 17.94 years old (SD 2.85). Most participants were male (83%, 17% female).

Table 2: Team demographics

Team number	Size	Age range	Mean age (SD)	Males (0%)	Females (0%)	Other
1	22	16-26	17.95 (3.03)	19 (86%)	3 (14%)	
2	20	16-19	16.95 (1.05)	18 (90%)	2 (10%)	
3	21	16-18	16.95 (0.87)	17 (81%)	4 (19%)	
4*	24	18-25	20.13 (1.68)	24 (100%)	0 (0%)	
5	18	16-18	16.78 (0.55)	14 (78%)	4 (22%)	
6	19	16-19	17.32 (0.95)	10 (53%)	9 (47%)	
7	20	16-19	16.70 (0.98)	16 (80%)	3 (15%)	1 (5%)
8*	18	17-26	21.69 (0.98)	18 (100%)	0 (0%)	
9	24	16-21	17.83 (1.05)	15 (62.5%)	9 (37.5%)	
10	23	16-20	17.85 (1.18)	18 (78%)	5 (22%)	
11	24	16-20	17.92 (1.14)	20 (83%)	4 (17%)	
12*	18	17-27	19.65 (2.80)	18 (100%)	0 (0%)	
13	18	16-21	17.83 (1.10)	14 (78%)	4 (22%)	
14	26	17-19	17.60 (0.76)	22 (85%)	4 (15%)	
15	25	16-18	17.36 (0.57)	17 (80%)	5 (20%)	
16	17	16-20	17.76 (1.15)	17 (100%)	0 (0%)	

N.B. * refers to a Service team. Team 16 borrowed an 18th team member from another team

2.3 Materials

Baker et al.'s (2005) review of available indicators of teamwork efficiency, structured around the Big Five theoretical model of teamwork processes (Salas et al., 2005), was adapted and extended for present purposes. Baker et al.'s research resulted in 23 behavioural indicators aligned to the five core teamwork dimensions and three teamwork coordinating mechanisms. The indicators were scrutinised by three of the authors with the aim of ensuring that an adapted and refined teamwork assessment tool was suited to both the JLFG context and present research aims. More specifically, the review sought to:

- Ensure that teamwork indicators remained relevant within a JLFG combat training context
- De-conflict compound indicators so that each measurement item had just one focal point
- Generate additional indicators of teamwork as appropriate to team-orientated combat training settings
- Ensure that the language used was clear and concise
- Ensure that each teamwork dimension was aligned to a minimum of three measurement items to enable the generation of internal consistency metrics (i.e. Cronbach's alpha)

In terms of measurement quantification, the review team reached a consensus over a combination of behaviourally-anchored rating scales (BARS) with a behavioural observational scale (BOS) element, presently referred to as a behaviourally-anchored observation rating scale (BAORS). The justification for this was that the JLFG competition sees many newly formed teams training to learn a historic combat drill. As such, the rating scale was designed to cater for the possibility that a team may lack the opportunity or capability to adequately demonstrate behaviour aligned to a particular teamwork indicator at the outset of the training programme, but should be able to demonstrate relevant behaviours as teamwork training progresses (albeit to various levels of accomplishment). Therefore, a structured 6-point Likert BAORS as depicted in Table 3 was used.

Table 3: Behaviourally-anchored observational rating scale

Observational Rating	Description
5 – Outstanding	Observations of team activities aligned to this behavioural indicator have surpassed all expectations.
4 – Good	Observations of team activities aligned to this behavioural indicator have been positive.
3 – Satisfactory	Observed team activity aligned to this indicator has been satisfactory and in line with expectations.
2 – Borderline	The team seem to have struggled to satisfactorily demonstrate behaviours aligned to this teamwork indicator.
1 – Poor	There has been a lack of appropriate teamwork behaviour aligned to this indicator (despite the team having had ample opportunity to manifest these behaviours).
0 - N/A	I have not had the chance to observe (enough) relevant team behaviours aligned to this item.

Before the JLFG event, the teamwork measurement protocol was scrutinised by two of the JLFG organisers in order to gauge face validity. Measurement elements were approved with only minor semantic changes. The final teamwork measurement tool contained 28 teamwork indictors (see Table 4): 21 of the indicators reported by Baker et al., (2005); four items resulting from the de-confliction of two compound indicators; and two newly generated indicators.

Table 4: Behavioural teamwork indicators

Teamwork dimension	Behavioural indicators
Communication - The efficient exchange of information between a speaker & relevant team member(s).	1. Team members stick to the use of relevant, clear & concise communication. There is no evidence of irrelevant chatter. ▲[1] 2. Speakers seek either visual or verbal confirmation to ensure that their message was adequately received. 3. Message recipient(s) appropriately acknowledge receipt of message(s) (e.g., nods, confirms). 4. Team members seek clarification of instructions or messages they are unsure of.
Shared mental models - Demonstrating knowledge of field gun task procedures, team strategies, & how the team members are required to interact.	5. Team members understand their individual roles in the JLFG task. ▲[2] 6. The team appear to be able to anticipate & predict each other's needs. 7. The team identifies problems in the teamwork & task strategies & adjust behaviour as necessary.
Mutual trust - Shared beliefs that team members will perform their roles & protect the interest of their teammates.	8. The team freely & openly share task information. 9. The team are willing to admit (& discuss) mistakes. Δ[1i] 10. The team appear willing to accept feedback. Δ[1ii]
Mutual performance motoring - The team's understanding of the team environment & the application of strategies to monitor teammate performance.	11. All of the team are proactive in identifying mistakes & lapses in team performance. 12. Team members are proactive in providing feedback to other team members. 13. Team members aide their fellow team members in correcting teamwork inefficiencies. ▲[3]
Backup behaviour - Anticipating other team member's needs. This includes the ability to shift workload to maintain performance when necessary.	14. Potential back-up providers recognise when there is a workload distribution problem in their team. 15. Any team member who is struggling promptly indicates that they require assistance. 16. Work responsibilities are easily reallocated in order to optimise team performance (e.g., giving more responsibility to underutilized team members).

Teamwork dimension	Behavioural indicators
Adaptability – Adjusting team strategy based on backup behaviours & appropriate allocation of team resources. May include altering a team strategy in response to changing conditions.	17. The team can proactively identify that a change has occurred, & develop/adopt a new plan to deal with changes. 18. The team identify opportunities for improvement. 19. The team demonstrate vigilance & recognise changes in the task environment.
Team orientation - Team members value each other's inputs & place the importance of team goals over individual goals.	20. Team members take into account suggestions provided by teammates. Δ^{2i} 21. The team collectively appraise suggestions from team members & determine what is likely to be most beneficial. Δ^{2ii} 22. There is evidence that the team are actively involved in information sharing & strategizing.
Leadership[a] - Directs & coordinates the activities of other team members, assesses team performance, assigns tasks, develops the team knowledge, skills & abilities, motivates team members, plans & organises, & establishes a positive atmosphere.	23. The team leader successfully facilitates team problem solving. 24. The leader expresses clear performance expectations & acceptable communication patterns. 25. The leader attempts to refine team strategy in order to combine individual team member contributions. 26. The leader seeks & evaluates information that might be affecting team functioning. 27. The team leader clarifies team member roles & inputs. 28. The team leader actively engages in structured team briefings & team feedback sessions.

N.B. Δ refers to a Baker et al. (2005) indicator that has been separated to de-conflict compound questions as appropriate to the JLFG context. ▲ refers to an additional scale item based on a teamwork review conducted by the authors from Cranfield's Applied Psychology Group. [a] 'Leadership' refers to the military trainer in this context.

2.4 Design

A repeated measures design was used. The teamwork assessment protocol required that teamwork ratings were elicited at the outset and end of the training programme (Day 1 and Day 5). Teamwork observations were collected from two perspectives - 1) trainers, and 2) team chaperones (pastoral figures from the teams' home institutes). There was a notable difference between teamwork measurement protocols - as trainers took the role of team leaders, they were not asked to rate their own team leadership in order to avoid self-report. Chaperones, however, were instructed to rate observed trainer leadership indicators. Field gun competition performance data from the tiered finals was available. Performance data was expressed as the time taken for the team to complete the field gun drill plus any time penalties (+3 seconds) added as a result of mistakes or imprecisions in the field gun drill. Better performance was reflected by quicker drill completion times.

2.5 Procedure

Ethical approval for the research was given by Cranfield University's Research Ethics Committee prior to the JLFG 2019 competition (CURES/8032/2019). Team survey packs containing two teamwork observation protocols (one for the trainer and one for the team chaperone), a cover note explaining the aims of the survey, and instructions on completing the teamwork ratings were compiled before the event. On Day 1, both the nature of the study and the researcher facilitating the teamwork study on-site were introduced to the trainers by the JLFG competition organisers. Introductions highlighted endorsement from the organisers and set expectations for the briefing and delivery of the research materials to follow.

Whilst briefing the trainers and chaperones on Day 1, the researcher took care to go over the instructions to promote understanding of the teamwork measurement protocol. This included asking whether raters had any queries over the behavioural teamwork indicators, seeking clarification that the teamwork measurement scale was understood, and answering any further rater questions. The

researcher remained available throughout the training week to respond to any further queries or issues raised. On Day 5, the researcher revisited team trainers and chaperones to facilitate the completion and collection of teamwork assessments.

3. Results

The present sample size (16 teams) did not afford either factor analysis or structural equation modelling of scale structure. Nevertheless, teamwork BAORS were pooled in order to determine whether further statistical analysis was appropriate based upon Cronbach's alpha (*α*) internal consistency metrics. All scales indicated an acceptable scale inter-item loading, as indicated in Table 5. Whilst α cannot attest to the structural validity of the measurement scale (e.g., Sijtsma, 2009), results did not negate the applicability of further teamwork sub-scale analysis.

Table 5: Cronbach's analysis

Teamwork dimension scale	Items	N	α
Communication	4	52	.86
Shared mental models	3	52	.86
Mutual trust	3	51	.84
Mutual performance monitoring	3	52	.93
Back-up behaviour	3	52	.88
Adaptability	3	51	.85
Team orientation	3	50	.90
Team leadership	6	25	.94

3.1. Teamwork analysis

Data collated (available at https://cord.cranfield.ac.uk/articles/Junior_Leader_Field_Gun_data_-_teamwork_impact_case_study/9767588) included teamwork scores from trainers and chaperones for 12 teams, chaperone-only data from two teams, and trainer-only data for a further two teams (detailing Day 5 measurements only). One issue was indicated during data screening in that *Leadership* variability was muted on Day 5 as ratings approached ceiling levels. Before trainer and chaperone ratings were combined, a two-way analysis of variance (rater x day of teamwork assessment) was conducted to ensure that there were no significant differences in teamwork ratings as a function of rater. Results indicated no significant effect of rater ($F(1,23) = .04$, $p = .84$) and no interaction between the type of rater and the day of teamwork measurement ($F(1,23) = 1.52$, $p = .23$).

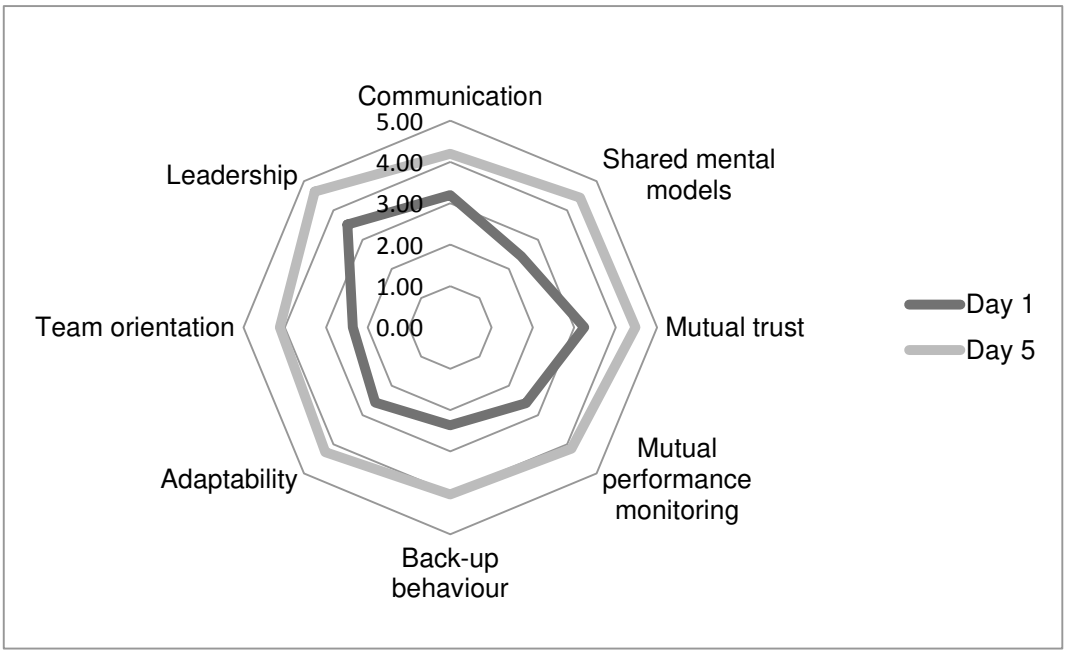

Figure 3: Teamwork JLFG 2019 Day 1 vs. Day 5

Figure 3 displays teamwork data for all of the teamwork dimensions for Day 1 vs. Day 5 of JLFG 2019 (noting that *Leadership* was rated by chaperones only). Results indicated that *Leadership*, C*ommunication,* and *Mutual trust* were rated as satisfactory at the outset of the training programme. *Team orientation*, *Back-up behaviour* and *Shared mental models* were observed to be the weakest teamwork dimensions on Day 1. By Day 5, all observations aligned to all teamwork dimensions were rated positively, with the biggest increments seen within *Shared mental models*, *Team orientation,* and *Adaptability*.

Table 6: Statistical teamwork dimension analysis

Teamwork subscale	**Day 1 mean (SD)**	**Day 5 mean (SD)**	***Difference* Δ**	***t*-test**	**Performance Pearson's *(r)***
Communication	3.20 (.97)	4.19 (.74)	*+0.99*	$t(24) = 4.27$***	$r(25) = .14$
Shared mental models	2.43 (1.00)	4.41 (.50)	*+1.98*	$t(24) = 11.00$***	$r(25) = -.03$
Mutual trust	3.19 (1.21)	4.46 (.60)	*+1.27*	$t(24) = 6.23$***	$r(25) = -.21$
Mutual performance monitoring	2.59 (1.22)	4.11 (.70)	*+1.52*	$t(24) = 8.43$***	$r(25) = .05$
Backup behaviour	2.37 (1.30)	4.02 (.95)	*+1.65*	$t(24) = 6.02$***	$r(25) = -.16$
Adaptability	2.53 (1.18)	4.23 (.95)	*+1.70*	$t(24) = 7.45$***	$r(25) = .00$
Team orientation	2.29 (1.09)	4.04 (.82)	*+1.75*	$t(23) = 9.52$***	$r(24) = .17$
Team leadership	3.44 (1.35)	4.64 (.77)	*+1.20*	$t(11) = 3.18$**	$r(12) = .69$*
Overall average	2.73 (.89)	4.23 (.63)	*+1.50*	$t(24) = 9.83$***	$r(25) = .07$

N.B. Δ refers to change in teamwork rating over the course of the JLFG event. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

Table 6 reports statistical analysis of teamwork performance data using IBM SPSS analysis software. Paired samples *t*-test comparisons, having excluded datasets with missing data, report that teamwork improved, on average, from 2.73 (borderline, approaching satisfactory) on Day 1 to 4.23 (positive) on Day 5. Further *t*-tests reveal significant improvements on all teamwork dimensions. Additionally, teamwork development (Table 6, Difference) was contrasted against

performance on the tiered JLFG 2019 competition finals. Teamwork measurement was unrelated to performance with one exception, *Leadership* was positively associated with performance ($r(12) = .69$, $p < .05$).

4. Discussion

The 2019 JLFG competition served as a case study for exploratory application of an adapted teamwork assessment protocol. The protocol was enacted to measure teamwork effectiveness at the start and end of a week-long residential training program. Data was collected from 16 teams. Complete datasets were available for 12 teams and partial data was available for a further four teams. Acceptable Cronbach's α from pooled teamwork sub-scales indicated consistency in scale unidimensionality permitting subsequent statistical analysis. Results revealed statistically significant improvements in all teamwork dimensions over the course of the JLFG event, attesting to the utility of the JLFG teamwork training programme for augmenting team processes. The greatest improvements were seen in teams' *Shared mental models*, reflecting gains in the collective understanding of team roles and task strategies as is fitting when training for a novel task in a newly formed team. The smallest improvement was seen in *Communication*. This might also be reflective of the nature of the task, i.e., a structured drill with clear standardised actions, requiring little in the way of communicative exchange once adequate mental models had been formed and task roles assigned, but is also attributable to the 'adequate' ratings of *Communication* at the outset of the training programme. It is worthwhile commenting upon two teamwork dimensions that were rated as 'satisfactory' on Day 1 of the competition week: *Leadership* and *Mutual trust.* It is likely that the novelty and prestige of the training event, the experience of trainers, and the motivational benefits of voluntary training participation (e.g., Patrick et al., 2012), when coupled with the demographics of participants and the competitive team environment, contributed to these initial satisfactory behavioural ratings.

Analysis of performance data from JLFG competition finals revealed little in the way of linkages between teamwork development and team outcomes (product measurement). One exception was the relationship between perceptions of trainer (#1 & #2) leadership and performance, with correlational analysis, (based upon data from 13 teams) indicating that improvements in leadership over the course of the training week were associated with slower performance times. This diverged from expectations. Present results regarding *Leadership* are to be interpreted with caution. *Leadership* ratings were drawn from a small sample and indicated reduced variability on Day 5, with ratings approaching ceiling levels.

The lack of any meaningful association between teamwork data and performance outcomes is contrary to expectations. Two explanations are offered for this: i) the unit of measurement; and, ii) the present operationalisation of performance. The preference for team-level measurement, whilst suited to richer teamwork process insights in field settings, limited sample size which may in turn have undermined the ability to adequately detect teamwork-performance associations. Alternatively, the lack of a discernible link between teamwork and performance might have been due to the narrow definition of performance used; presently, only the final competition trial of Day 5 was analysed. This represents a fragment of the complete field gun drills conducted over the course of the training programme. A more fitting way to measure team performance might have been to record an average of drill performance throughout the competition heats, or capture of the best recorded drill time throughout the training week, regardless of whether that may have resulted from a competition trial or a practice trial performed under competition conditions. A justification for considering practice trial data might be to rule out the pressures and dynamics of the competition

day. In the present programme, by competition day (Day 5), teams are more likely to have accumulated fatigue and/or injuries and may be subject to 'choking' under pressure (e.g., Gröpel & Mesagno, 2017).

4.1 Methodological evaluation

In interpreting research findings, some methodological limitations that may impact upon the reliability of the results should be noted. Firstly, having teamwork assessors complete the same behaviourally-anchored observational rating scales (BAORS) in close succession, coupled with the fact that raters retained their Day 1 ratings and had the chance to review them at any point, might have resulted in some inflated teamwork associations due to common method variance (e.g., Podsakoff et al., 2003). A related teamwork measurement factor is that ratings were not made by formally trained teamwork observers as recommended in the teamwork literature (e.g., Goodwin et al., 2018; Wildman et al., 2013). Raters (both trainers and chaperones) were briefed and supported in teamwork rating application but were not given the opportunity to practice teamwork BAORS application prior to the study. This may mean that there is some undue variability in how the teamwork observations were made. Secondly, whilst all trainers were familiar with the core Naval teamwork values, and had JLFG team training experience, none had received formal, explicit training on teamwork interventions. Future research might benefit from considering what train-the-trainer interventions might support teamwork training in combat settings. A final limitation entails the practicalities of collecting teamwork survey packs on JLFG Day 5. Anecdotal observations from the on-site field researcher indicated that those returning survey packs found the measurement tools to be understandable, transparent and easy to apply. However, it may be inferred from the missing data that in reality there were difficulties in completing the paperwork. This could have been due to unrecognised issues with the application of the measurement tool, or due to practical difficulties with organisation, scheduling and time management at the end of a busy competition week.

A relevant nuance of the present study is that the Service teams involved (n = 3) would have been familiar with combat training drills, military instruction, and may have had some exposure to the field gun drill previously. Likewise, a small number of the non-Service JLFG participants may have participated in previous JLFG competitions (numbers unknown). Whilst this is worth noting, it is anticipated that the recency of team composition and role assignment would have been enough to ensure that no team were afforded any undue advantage.

Another relevant factor is that newly formed teams are more malleable and so stand to benefit the most from teamwork training (McEwan et al., 2017). It is not apparent whether present trends in teamwork assessment could be replicated with pre-established teams. Other factors that may affect the generalisability of results beyond the present combat contexts include the nature of the team. The present research supports teamwork as aligned to 'action' teams (Humphrey et al., 2009; Sundstrom et al., 1990). It is not envisioned that the tool would readily translate to other team types such as project teams, committees, or virtual teams without further refinement of the teamwork protocol (Bell & Kozlowski, 2002; Sundstrom et al., 1990).

Despite the limitations, we propose that the 2019 JLFG competition proved advantageous in obviating some of the typical issues and limitations associated with naturalistic studies. The competition saw multiple teams simultaneously immerse themselves in a standardised combat drill in an applied training environment. All teams were paired with a dedicated and experienced trainer doubling as a teamwork coach and observer-mentor. This afforded team-level analysis of an in-situ training programme populated with real-time practice and performance activities requiring a variety

of trainee active engagement strategies (Hughes et al., 2016; McEwan et al., 2017; Salas et al., 2012).

4.2 Conclusions

A 28-item teamwork assessment protocol based upon the practical application of Salas et al.'s (2005) 'Big Five' model of teamwork was successfully used to analyse teamwork development within a research-accessible combat training context. Teamwork measurement was applied at the team level of analysis to enable dynamic team processes to be evaluated. The research has benefitted from exploiting best practice in teamwork measurement, specifically the avoidance of potentially biased self-report, the unobtrusive collection of teamwork data, and the assessment of teamwork changes over time (Mathieu et al., 2017; Salas et al., 2018).

Changes in teamwork ratings by the end of the JLFG 2019 training programme indicated positive gains on all teamwork dimensions. Such changes were attributed to the event programme and also the provision of experienced team trainers doubling as observer-mentors. Due to indications that some teamwork competencies are both transferable and of benefit in multiple environments (Salas et al., 2018), the present research validates the Royal Navy JLFG competition as a valuable training and development opportunity for the participants involved.

Teamwork efficiency gains, such as those reported here, are likely to be found in other defence training contexts involving the compilation of new teams. Should there be opportunity to observe teams in action, the teamwork assessment protocol could be applied to track teamwork improvement over time. Example defence environments that should benefit from this include i) the training of new teams within artificial socio-technical environments such as aircraft simulators, and ii) collective training environments requiring the effective interoperability of teams from differing backgrounds. Tracking teamwork in such contexts would enable the objective assessment of team performance, provide a firm basis for the development of formative and summative feedback, inform coaching of efficient teamwork behaviours, and ultimately lead to improved teamwork processes. Non-defence contexts in which team evaluation would be advantageous include the simulated training of crisis teams as found within the medical and firefighting contexts. It is anticipated that embedding team observers who are knowledgeable about teamwork science could be achieved via the generation of a targeted train-the-trainer educational package. Future teamwork research efforts should be prioritised around the need to i) further refine and validate the structural integrity of the teamwork measurement tool, ii) devise train-the-trainer teamwork interventions, and iii) assess the applicability of the teamwork measurement protocol developed for use in further defence settings.

Acknowledgements

Thanks are owed to all Junior Leaders' Field Gun competition organisers and trainers. Further thanks are extended to event sponsors - the Royal Navy and Royal Marines Charity, and also the Baker Dearing Educational Trust. Thanks to the Commanding Officer at HMS Collingwood and all his staff for accommodating the event within a vibrant Royal Navy training environment. Special thanks are owed to the Royal Navy personnel responsible for organising the JLFG event and that have aided in facilitating this study including, CPO Keith 'Frenchy' Marsay, WO1 Paul 'Tiny' Nash and WO1 Stuart Clayton.

Funding details

This work was supported by Cranfield University's Higher Education Innovation Fund. [PI Lisa Humphreys, Award title: 2018-19 HEIF]. The funding source had no involvement in study design, data collection, analysis and interpretation of data, writing the manuscript or the decision to submit research for publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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*Declaration of Interest Statement

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☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: