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Cover Page Footnote

The work presented in this paper was mainly performed during the internship of Andres Käosaar at the Advanced Concepts Team (ACT) of the European Space Agency (ESA).

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Using Behavior Sequence Analysis to Study Teams During Long-Duration Isolation and Confinement

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Abstract

With a renewed impetus and appetite for human space exploration, both government-funded agencies and private companies are focusing on longer and farther crewed missions into the solar system. Such space missions rely on highly interdependent teams living and working together in isolated, confined, and extreme (ICE) environments. Understanding the behavioral patterns of teams in ICE environments is, thus, paramount for the future success of such missions. Due to the complexity of studying ICE teams, several researchers have called for methodological innovations to advance knowledge in this area. In the current research, a proof-of-concept methodological approach is introduced that provides a potential solution for several shortcomings of traditional approaches. A behavior sequence analysis (BSA) approach was used to analyze two historical polar expedition journals, resulting in data depicting transitions from antecedent behaviors or emotions into sequitur behaviors/emotions amongst the expeditions' teams. The data are described, illustrated by corresponding state transition diagrams, and possible ways of interpreting the data are introduced. Applications and limitations of the used approach as well as possible future developmental steps for the method are discussed. In general, BSA was demonstrated as a potentially useful methodology for extracting meaningful data from long texts, showing detailed connections between a myriad of events, behaviors, and emotional responses of individuals and wider teams.

Keywords: team dynamics, space exploration, polar expedition, teams, behavioral sequence analysis

Introduction

Human spaceflight missions subject their participants to a number of extremes of risks, including a range of physical challenges and isolation and confinement (Patel et al., 2020). In addition to individual psychological resilience, team dynamics governing small interdependent space teams greatly influence mission success (Kanas, 2014; Kass & Kass, 2001; Landon et al., 2018). The distance from Earth and resulting communication latency that will characterize future long-duration exploration (LDSE) missions mean that the crews will have to operate more autonomously than is the case on the International Space Station (ISS). Given this increased independence, on deep-space missions internal team dynamics will become even more critical for maintaining the safety, performance, and physical and psychological health of the crew (Caldwell, 2006; Landon et al., 2021). Research on teams can offer insight into how certain dynamics might evolve in interdependent team units and potentially provide information to mitigate the significant individual and interpersonal challenges of exploring beyond Earth's orbit. The need for this understanding is emphasized in both NASAs Human Research Roadmap (NASA HRP, 2015) and the European Space Agency's (ESA) SciSpace exploration white papers (ESA, 2021).

Whilst scholars have shown an interest in team dynamics in space for a number of years, team-related data from actual human spaceflight missions are limited (Käosaar et al., 2022). Instead, researchers have focused their attention on collecting data from people in so-called isolated, confined, and extreme (ICE) settings such as space simulations (Sandal & Bye, 2015), submarine crews (van Wijk & Dalla Cia, 2016), and polar expeditions (Kjærgaard et al., 2015). ICE environments are appealing for this purpose because individuals in those contexts are expected to encounter a similar psychological experience as would be faced in space (e.g., isolation, limited possibility for evacuation, proximity with others) (Burke et al., 2018; Suedfeld, 2010). Polar expeditions and deployments at polar research bases have most commonly been used as

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analogs for studying the social psychology of human spaceflight, especially regarding missions of long duration without resupply (Gunderson, 2012; Landon et al., 2018; Palinkas, 2001; Suedfeld, 2018). Building on this long history, in the present study, data from polar expeditions have been used with a notion that these findings should be generalizable to the wider ICE context and LDSE mission sets (e.g., Kjaergaard et al., 2022; Leon et al., 2011).

Although many studies have used genuine teams or very realistic experimental setups for studying team phenomena in ICE environments, these studies typically lack the ecological validity (because of the incomparable or artificially created demands) to support generalization of findings to LDSE missions. In the past, it has been argued that historical expeditions, where teams had no contact with mission support nor friends or family and endured high levels of uncertainty, are potentially closer to the situation future astronauts travelling to Mars might experience (Suedfeld, 2010). Although there have been attempts to examine psychological dynamics captured in historic exploration material (e.g., Mocellin & Suedfeld, 1991), the full potential of these texts for helping understand the links between unfolding events and behaviors, especially those pertaining to team functioning, has not been realized. An additional limitation of other prior work on extreme teams is that studies have tended to focus on just a few variables at a time (Golden et al., 2018), neglecting the complex dynamics that shape and are shaped by team phenomena (Driskell et al., 2018).

In this paper, analysis of archival exploration data combined with a novel analytical approach was used to show how existing historical accounts of human exploration can still be used for gathering meaningful insights about teams in ICE contexts (Stuster et al., 1999; Suedfeld, 2010). For this proof-of-concept study, two historical polar journals were analyzed using a newly developed codebook and temporal analysis designed to map complex pathways, behavior sequence analysis (BSA; Marono et al., 2017). BSA has been demonstrated as a useful approach for studying patterns of human behavior in diverse areas including in social psychology (Marono et al., 2017), medical practice (Townsend et al., 2016), and forensic settings (Marono et al., 2020). Related methods have also initially been applied to examine the coping behavior of a team in polar expedition settings (Smith et al., 2019). Despite that initial work, due to the early-stage explorative nature of the present approach, *a priori* hypotheses were not tested. That being the case, it was anticipated that certain sequences might be observed. For example, in past research worsening environmental conditions have been linked to feelings of stress (Leon et al., 2011), which have tended to activate team interactions such as planning and problem-solving in response (Kjærgaard et al., 2015). While a small number of probable sequences might be predicted, the complex temporal pattern of event–behavior transitions of teams in ICE contexts is not clear and thus was the main focus of the current study: to map indicator pathways (events, behaviors, and emotional experiences) that inform on social dynamics in ICE environments.

Method

BSA combined with practices used in historiometric research was used to generate insights from the historic polar expedition material studied in this work (Burke et al., 2021; Keatley, 2018; Keatley & Clarke, 2020).

Behavior Sequence Analysis

BSA follows three sequential steps: (1) from a selected set of data (e.g., journals), break down, or *parse*, all relevant observed behaviors into specific categories, then (2) *categorize* the list of behaviors, and finally (3) statistically *analyze* the transitions between behaviors, highlighting which are occurring significantly above the level of chance (Keatley & Clarke, 2020). Part of the result of this analysis is a flow chart (for an example, see Figure 1) that visualizes a network of transitions between observed behaviors (and other coded indicators of interest, e.g., emotional states), with additional information on the observed likelihood of each transition, i.e., standardized residuals.

Data Sources

Two expedition journals were selected for this study—Captain Robert Falcon Scott's journals from the British Antarctic Expedition (Scott, 2005) and Sir Ernest Shackleton's *South* (Shackleton, 1919). Both books were written by the expedition leaders, containing only the perspective of the leader, describing meaningful experiences across the whole expedition, and written in a detailed manner. In other aspects, the original plan of the two expeditions was fairly similar, increasing the homogeneity of the current sample. Despite their contextual similarity, the sources had very different events over the course of the expeditions and different outcomes. This offered a chance to test the discriminant validity of BSA as applied to historic exploration material.

Events

Distinctive events from the journals were identified by the authors. An 'event' was defined as a particular occurrence in the journal entries that contain descriptions of what occurred at a particular point in time (e.g., 34 lines of Shackleton's journal that cover the sinking of their ship and the psychological aftermath were extracted as a distinct event and labelled as 'Sinking of Endurance'). Identifying events in this way provides a parsed, temporally organized

data source that can be used to explore the effects of events on the psychology and team dynamics of the expeditioners as they unfold (Burke et al., 2021). For Scott's journal, 14 events were distinguished and for Shackleton's, 8 (Table 1). The shortest event lasted a few hours covering the fall of a part of Scott's expedition party into a glacier crevasse and the rescue operation. The longest event lasted for a month, being Scott's 'Last March'—the month starting with the death of P.O. Evans, the first member of Scott's summit party to die—and ending with the death of the last three members of the five-member summit party.

Data Extraction

An initial codebook was created, based on the expertise of the authors and content of team models described in existing literature (from Burke et al., 2018; Golden et al., 2018; Käosaar et al., 2022). To ensure that the codebook reflected the detail of raw data related to different events, behaviors, and emotional experiences that arise on expeditions, additional variables were added to the codebook during the coding process to allow a more detailed level of granularity (e.g., "animals fighting," "diminishing supplies," and "ship sunk"). The new codes added were specific to the event (e.g., ship sunk), thus not possibly applicable for previous events, but nevertheless when a new code was added to the codebook, previous codes were revisited and analyzed again to ensure that no existing coded data needed revision. This combined top-down and bottom-up approach contributed to the development of a comprehensive coding dictionary.

The coding process took place as follows. First, the primary coder coded the events from Scott's journal. Then two sets of ten 10-line samples were extracted from the coding document, one set for three and another for two authors, and each of the authors of the research independently analyzed the original coding and a discussion was held for reaching agreement. After the next round of coding by the primary coder, the coding of one whole event was validated by the BSA specialist of the research team. Full agreement on the codes was reached before the coder completed coding all events from the first data source. For the second source, the primary coder coded the whole journal and then a second trained coder reviewed existing codes, commenting when needed. A discussion between the two coders was held until full agreement on the coding was achieved.

Since the bulk of the codebook had been written *a priori*, and a considerable number of codes were specific to individual events, many of the variables of the total 224 in the codebook were used infrequently and 37 of the initial list were not used at all. Furthermore, a proportion of variables were semantically similar or could be categorized in the same way in the context of the expeditions (e.g., "bad wind" and "bad weather" had the same effect on the team), so to reduce complexity and allow for more coherent and clear results, the codebook was degranulated. For example, two variables were combined if they were semantically similar and were being used interchangeably by the two coders. This process was discussed and agreed by all the authors and is an accepted approach in BSA (Keatley & Clarke, 2020). As a result, the degranulated coding book, on which the results of the current study are based, consists of 93 distinctive variables.

To produce a comparable data set, the two expeditions were split into three parallel phases (beginning, middle, and end)—a common practice in BSA methodology to allow for a more global temporal analysis (Fossi et al., 2005). This led to six sets of event sequences—one set for each phase (i.e., beginning, middle, end) for both of the sources (i.e., Scott and Shackleton)—consisting of 3399 code entries in total (Table 1).

Data Analysis

BSA is typically performed in two stages—first frequency counts for each of the codes are produced, as described above, and then sequences are modelled. Central to BSA is a focus on the transitions between pairs of behaviors, emotions, or events (Keatley, 2018). Both the frequency of transition observations (n) and standardized residuals (SR) were calculated between antecedent variables and sequitur variables. On the basis of these statistics, state transition diagrams were drawn, indicating the most frequent and above-level-of-chance transitions. Although it seems tempting to derive longer chains of connected behaviors from state transition diagrams (see Figure 1 for an example), for avoiding overfitting of data, the analyses are conducted only on pairs of behaviors. This is referred to as lag-one BSA, the preferred statistical analysis in BSA (Keatley, 2018). All the transition lines in the presented diagrams are significant ($p < 0.005$). To aid interpretation, meaningful result cutoff criteria of $n \geqslant 2$ and SR $\geqslant 2$ have been applied (Keatley, 2018).

Results

Scott's Expedition

Phase 1: Sailing to Antarctica, Preparing for the Summit, and Wintering

For Phase 1, 58 transitions were observed $n \geqslant 2$ times ($M = 3.48$, SD = 2.15) with SR $\geqslant 2$ ($M = 3.81$, SD = 2.11). The most frequent transitions being "some success" → "problem encountered" ($n = 11$, SR = 5.39), "taking action" → "task-related difficulty" ($n = 10$, SR = 3.19), "planning" → "taking action" ($n = 9$, SR = 2.84), "environmental change" → "some success" ($n = 8$, SR = 3.57), and "condition improving" → "some success" ($n = 7$, SR = 4.53).

Table 1
The phases, their corresponding framing events, and the number of events and codes of the sources.

		Scott	Shackleton
Phase 1	Framing events	Departure from New Zealand until the beginning of the summit	Departure from South Georgia until abandoning the Endurance
	Number of events	10	3
	Number of codes	845	258
Phase 2	Framing events	Beginning of the summit until the summit	Abandoning the Endurance until the departure towards South Georgia island
	Number of events	2	3
	Number of codes	583	449
Phase 3	Framing events	Return from the summit	The endeavors on the way to Stromness whaling station
	Number of events	2	2
	Number of codes	880	384
Number of lines of text		3918	2069
Number of codes		2308	1091

From the state transition diagram in Figure 1, it is apparent that "some success" had two significant sequiturs (i.e., following behaviors): "problem encountered" (n = 11, SR = 5.39) and "task success" (n = 5, SR = 3.65). Based on these findings, it seems that in this part of the mission small successes tended to be followed by the report of new problems. To a lesser degree, small accomplishments did, at times, activate other successes and reports of progress. These findings speak to the uncertain conditions encountered in extreme polar environments, where the same experience can lead to very different outcomes.

Other prevalent transitions speak strongly of the harsh Antarctic environment and associated challenges: "taking action" often leads to "task-related difficulties" (n = 10, SR = 3.19) emphasizing why "planning" tends to be a necessary step before "taking action" (n = 9, SR = 2.84). "Environmental change" or "improving conditions" often led to "small success" on the task at hand (n = 8, SR = 3.57 and n = 7, SR = 4.53 respectively), as would be expected in harsh conditions, where the ease of a task depends to a great extent on the weather and/or surface conditions.

The transitions with the highest above-level-of-chance identified (thick black arrows in Figure 1) further elaborate on the difficulties of the environment. For example, "meeting others" was often followed by being "fatigued" (n = 2, SR = 11.68) and "discomfort" was associated with "continuous strain" (n = 2, SR = 10.41), i.e., the stressors being chronic rather than acute. Environmental difficulties trapped the crew in their habitat (n = 3, SR = 8.85) and when the situation was used for alternative activities ("use the situation for alternative activities") instead of directly expedition-related tasks (e.g., playing football), "positive physical fitness" was reported (n = 2, SR = 8.43). These sequences demonstrate how unfolding events and behaviors can shape and be shaped by team experiences.

Phase 2: Summit

For Phase 2, 27 transitions with $n \geqslant 2$ (M = 3.93, SD = 2.48) and with SR $\geqslant$ 2 (M = 4.52, SD = 2.40) were observed. Although the number of significant transitions is almost two times smaller, the means of both occurrences and SR are noticeably higher than in Phase 1. The lack of diversity in transitions as compared to the previous phase might indicate that the summit to the South Pole was more monotonous than the preparations (previous phase)—this is also visible from the state transition diagram (Figure 2). The most frequent transitions extracted during the Phase 2 were: "condition worsening" → "task-related difficulty" (n = 11, SR = 6.32), "some success" → "condition worsening" (n = 10, SR = 5.8), "environmental difficulties" → "discomfort" (n = 7, SR = 8.2), "task-related difficulty" → "fatigue" (n = 6, SR = 6.19), and a recursive transition of "negative affect" → "negative affect" (n = 6, SR = 3.11). The strong significant transitions also included "holiday" being related to "positive food experience" (n = 2, SR = 11.20), "habitat difficulties" associated with "discomfort" (n = 2, SR = 8.58), "environmental difficulties" followed by being "stuck in the habitat" (tents) (n = 3, SR = 7.15), and "equipment issues" leading to "taking action" (n = 4, SR = 6.64).

These transitions provide a window of insight into the difficulties that Scott's polar expedition team endured after leaving the base camp—each transition adds another layer into portraying a picture of a tough environment and related hardships. These transitions reinforce the tendency described in Phase 1 of Scott's expedition, where small successes were followed by additional problems and strain, creating a perception of a tough expedition with frequent difficulties and newly evolving challenges.

The Phase 2 state transition diagram (Figure 2) presents more discrete clusters of transitions—although due to the lag-one character of BSA the longer transition chains do

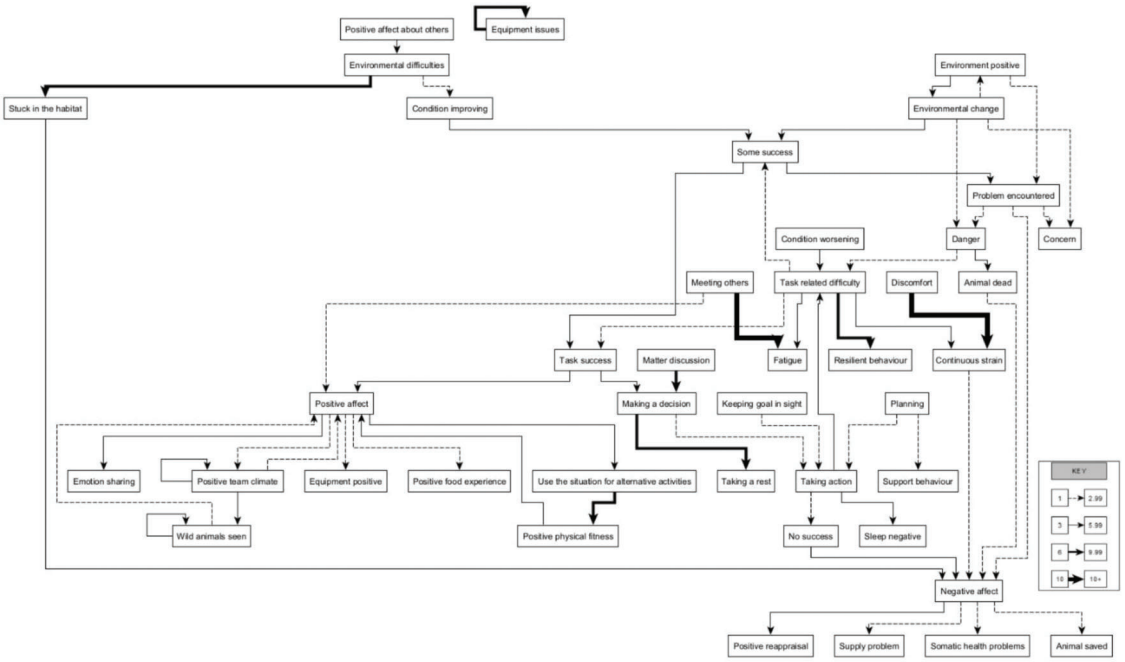

Figure 1. State transition diagram of Scott's expedition's Phase 1.

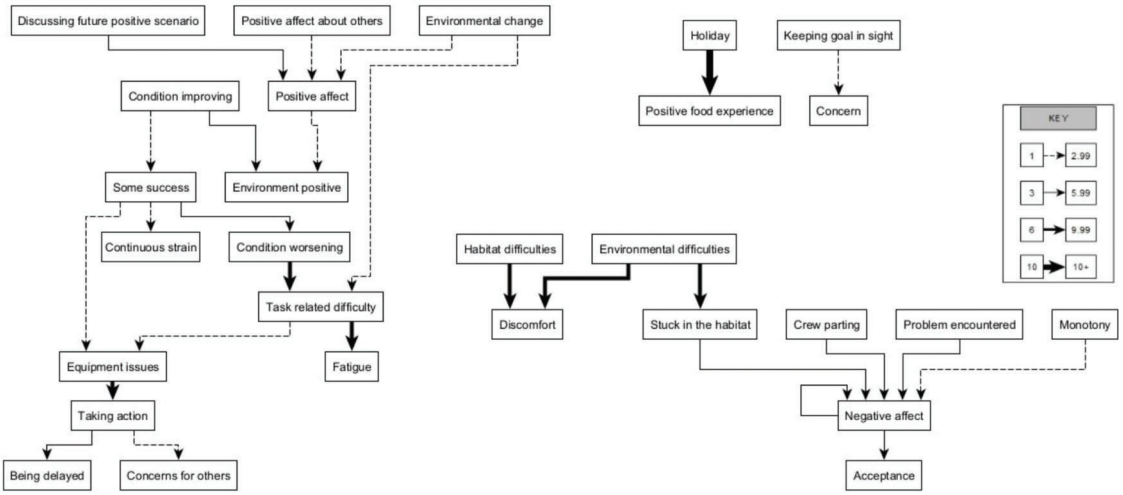

Figure 2. State transition diagram of Scott's expedition's Phase 2.

not show actually connected transitions of behaviors (i.e., "condition worsening" leads to "task-related difficulty," *and then* to "fatigue"), it is still possible to see how specific behaviors and happenings might unfold and indirectly lead to other experiences. The transition chains portray an emotionally diverse endeavor—"habitat difficulties" (e.g., wet sleeping bags and snow in the tent) were associated with reports of "discomfort" ($n = 2$, SR = 8.58) and "environmental difficulties" with being "stuck in the habitat" ($n = 3$, SR = 7.15; for the transition of "environmental conditions" and "discomfort" $n = 7$, SR = 8.58). Moreover, "stuck in the habitat" ($n = 3$, SR = 5.82), the departure of part of the crew back to the base camp ("crew parting," $n = 2$, SR = 4.44), and "problems encountered" ($n = 3$, SR = 3.49) were linked to "negative affect". In turn, "negative affect" was significantly followed by "acceptance" of the situation ($n = 2$, SR = 4.52). On the other hand, discussing "future positive scenario" ($n = 2$, SR = 4.08) and "positive affect about others" ($n = 4$, SR = 2.82) were solely positive events and not connected to other variables.

Phase 3: The Last March

There were 73 significant transitions observed in Phase 3 ($M(n) = 3.53$, SD(n) = 2.29, M(SR) = 3.79, SD(SR) = 1.57). As can be deduced from the statistics but seen also from the state transition diagram (Figure 3), the return journey from the summit was much more complex in behavioral patterns than either of the previous phases.

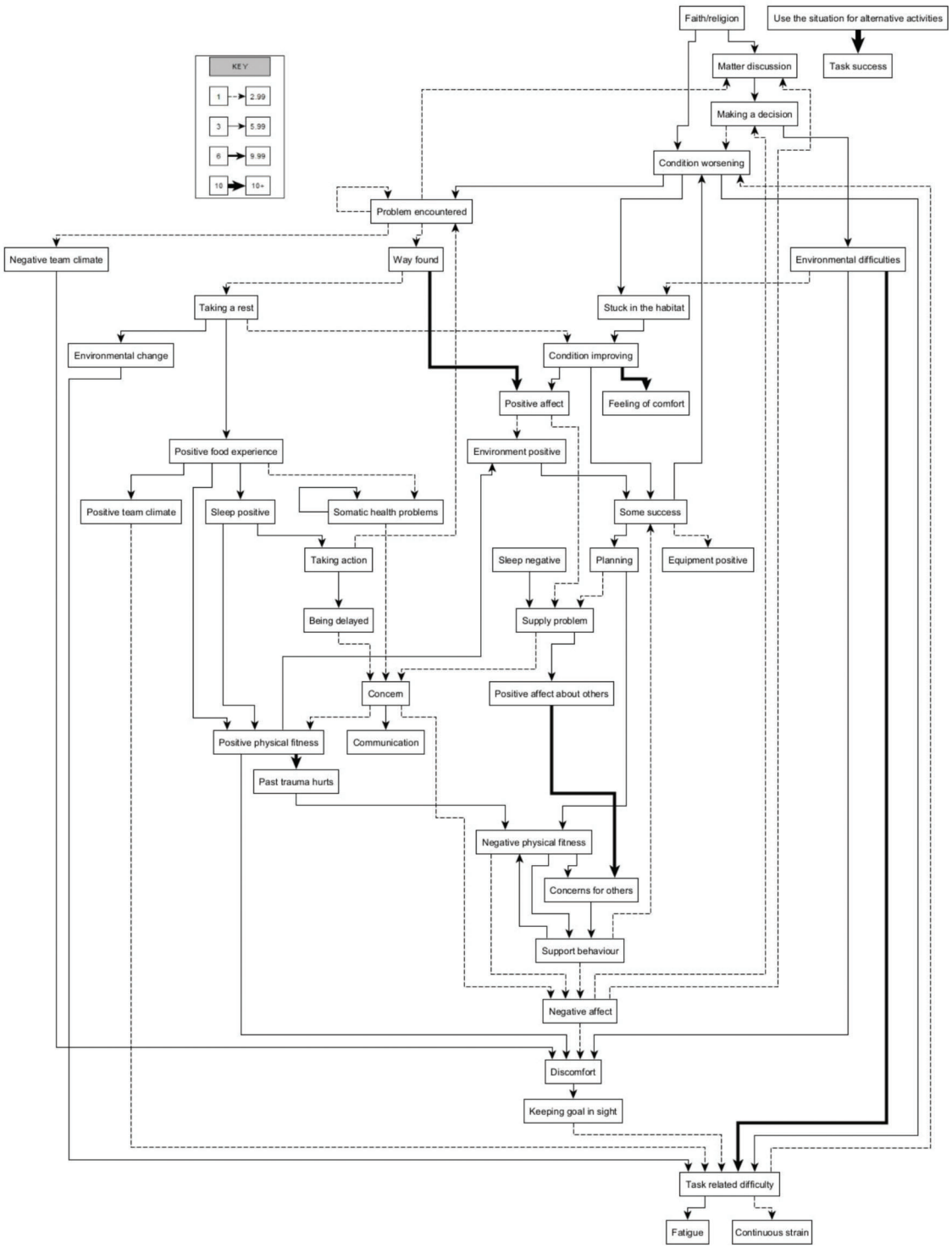

Figure 3. State transition diagram of Scott's expedition's Phase 3.

The most frequent transitions being: "environmental difficulties" → "task-related difficulty" (n = 11, SR = 6.26), "way found" → "positive affect" (n = 10, SR = 6.40), "condition worsening" → "task-related difficulty" (n = 10, SR = 4.53), "condition improving" → "some success" (n = 8, SR = 5.18), and "some success" → "condition worsening" (n = 8, SR = 4.01). Other significant transitions included "use the situation for alternative activities" → "task success" (n = 2, SR = 11.03, alternative activities being collecting geological samples), "positive physical fitness" → "past trauma hurts" (e.g., past frostbite; n = 2, SR = 7.39), "positive affect about others" → "concerns for others" (n = 2, SR = 7.02, although a team member was described as being

strong, the situation of their mental state was worrying), "condition improving" → "feeling of comfort" (n = 2, SR = 6.04), and "somatic health problems" followed by additional "somatic health problems" (n = 5, SR = 6.00).

In the last part of Scott's party's expedition, there were more transitions related to discomfort and negative affect than in previous phases, but also more nuanced connections between behaviors and emotions, and mixed negative–positive or positive–negative transitions: "positive food experience" → "positive team climate" (n = 2, SR = 3.84, reflecting how the negative affect stemming from difficult situation was being mitigated through eating better), "sleep positive" (i.e., more and deeper sleep than usual) → "positive physical fitness" (n = 2, SR = 4.77), and "positive physical fitness" → "past trauma hurts" (n = 2, SR = 7.39). Moreover, a variable "faith/religion" emerged (followed by "condition worsening" [n = 4, SR = 3.51] or "matter discussion" [n = 2, SR = 3.20]) in the last phase of the expedition that was not apparent in the previous phases—a sign of extracting strength and/or hope from external divine sources in the difficult situation the team found itself in.

Shackleton's Expedition

Phase 1: Travel to Antarctica and Being Stuck in Endurance Until Abandoning the Ship

For Phase 1 of Shackleton's expedition, 25 transitions observed $n \geqslant 2$ times (M = 2.52, SD = 1.08) and with SR $\geqslant$ 2 (M = 3.26, SD = 1.08) were found. The most frequent transitions being "taking action" → "task-related difficulty" (n = 6, SR = 2.88), "taking action" → "task success" (n = 5, SR = 3.61), "negative affect" → "planning" (n = 4, SR = 2.63), "taking action" → "no success" (n = 4, SR = 2.09), and "planning" → "danger" (n = 3, SR = 2.89). Other significant findings included expressing "concern" → "sleep negative" (n = 2, SR = 6.24) and "danger" being followed by "person saved" (n = 2, SR = 5.97).

Both the number of events and the number of corresponding lines of text in Shackleton's journal are close to three times lower than Scott's (see Table 1). This seems to reflect also in the number of the transitions observed (25 versus 58 in the case of Scott's Phase 1), but not in the mean value of SR. This might also be explainable through the fact that the destruction of Endurance was a slow process not so rich in distinctive events—the slow but harsh process reflects also in the character of the corresponding transitions, which are mostly task-related, e.g., "taking action" → "task success" (n = 5, SR = 3.61). From the results of the analysis (see Figure 4) it is visible that most of the activities and thoughts of the leader of the expedition revolved around dealing with executing tasks in order to use the environmental conditions for the best of the expedition.

Phase 2: The Endeavors on the Ice Until the Departure of the Party Towards South Georgia Island

For Phase 2, 36 transitions with $n \geqslant 2$ (M = 2.61, SD = 0.99) and with SR $\geqslant$ 2 (M = 4.04, SD = 1.85) were observed. Although the number of significant transitions increased by almost 30% compared to Phase 1, the mean number of observations has remained similar and the value of SR increased significantly ($t(57.6) = -2.09$, $p < 0.05$). This indicates that the variability of connections between the different behaviors has increased, but the statistical strength of these transitions has increased at the same time, increasing the predictive value of the transitions.

The most frequent transitions observed for Phase 2 were "equipment issues" → "negative affect" (n = 5, SR = 4.77), "environmental change" → "danger" (n = 5, SR = 3.28), "negative affect" → "environmental change" (n = 5, SR = 2.51), "environmental difficulties" → "discomfort" (n = 4, SR = 5.90), and "task success" → "positive affect" (n = 4, SR = 4.71). Other significant transitions included "positive attitude" → "positive team climate" (n = 2, SR = 7.75), "communication" → "no success" (i.e., not getting a signal back from the others,

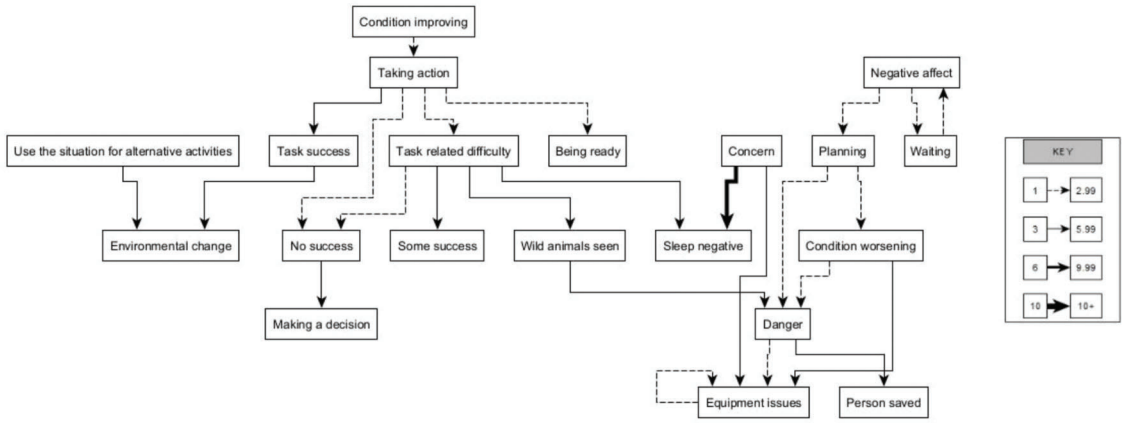

Figure 4. State transition diagram of Shackleton's expedition's Phase 1.

n = 3, SR = 7.63), "supplies extracted" (i.e., from Endurance or killing animals) → "positive food experience" (n = 2, SR = 7.47), "meeting others" → "positive affect" (n = 3, SR = 7.43), "sleep negative" → "wild animals seen" (n = 2, SR = 7.22, e.g., sleep was disrupted by braking ice and killer whales seen in the ocean between broken ice sheets), and "positive food experience" → "positive physical fitness" (n = 2, SR = 6.39).

Comparing Shackleton's Phase 2 to Phase 1, a shift from more task-related frequent transitions towards more environment-related transitions can be seen. The expedition crew was now exposed to the elements, trying to get on a secure foothold on the melting and moving ice patches, potentially explaining this shift in observed transitions (see Figure 5). Also, more apparent in these results are the unusual transitions, e.g., "positive affect" → "somatic health problems" (n = 2, SR = 2.56), "sleep negative" → "wild animals seen" (n = 2, SR = 7.22), and "enjoying the environment" → "negative affect" (n = 2, SR = 4.48). These connections may portray a realistic picture of the disorder of the events and behaviors the crew endured in this unstable phase of the expedition, resulting in curious and somewhat contradictory transitions.

Phase 3: The Small Party's Adventure to Stromness Whaling Station

There were 38 significant transitions observed in Phase 3 ($M(n)$ = 2.61, SD(n) = 1.00, M(SR) = 3.38, SD(n) = 1.29). The most frequent transitions being "taking action" → "task-related difficulty" (n = 7, SR = 3.60), "condition worsening" → "danger" (n = 4, SR = 6.30), "danger" → "negative affect" (n = 4, SR = 4.99), "task-related difficulty" → "task success" (n = 4, SR = 4.14), and "environmental difficulties" → "discomfort" (n = 4, SR = 3.43). Other strongly significant transitions included "no success" → "continuous strain" (n = 2, SR = 7.27), "continuous strain" → "sleep negative" (n = 2, SR = 6.22), and "taking a rest" → "positive food experience" (n = 3, SR = 6.06).

Phase 2 and Phase 3 of Shackleton's expedition are fairly similar (see Figures 5 and 6)—the main issues revolving around the change of environmental conditions and associated danger, which reflects the real situation, since the main difference between the expedition character of Phase 2 and Phase 3 lies in the fact that in Phase 3 the crew consisted of a fragment of the whole crew and now the team whose behaviors are described had a specific goal in sight to pursue.

Discussion

The aim of the current study was to test a novel analytical method for systematically mapping and understanding dynamics in team experiences in ICE contexts, i.e., the patterns of interplay between different events, behaviors, and affective responses. For both analyzed expeditions, and their discrete phases, unique sets of transitions were extracted depicting the complex web of interactions between unfolding events and responses over the course of the endeavors. To our knowledge, this is the first attempt to apply BSA methods to historic exploration material to unlock new insights into social psychology in ICE environments. This proof-of-concept work provides the foundation for potentially informing a wider research program utilizing preexisting exploration material, which could be used to support the development of anticipatory decision-making models for teams in ICE environments, and in particular, on future space explorations away from Earth.

For Scott's expedition, the transitions of the first phase revealed what would be expected in an ICE environment situation—a number of different stressors and challenges resulted in problems that needed to be dealt with while positive aspects were also reported (Leon et al., 2011). On the other hand, the second and third phases showed more intense environmental difficulties, leading to increasing levels of discomfort and problems. While the transitions of the second phase paint a dire picture, the theme gets stronger in the third phase where issues get more serious (e.g., supply problems and somatic health problems). Overall, the transitions portray a gradual worsening of the situation for Scott's expedition and increasing acuteness of the difficulties they encountered.

The transitions extracted from Shackleton's journals show a somewhat consistent pattern—the first phase was characterized by different problems requiring a corrective response but the second and third phases presented a more dynamic picture with newly emerging demands and connections with other variables. In the case of Shackleton's expedition, more positive affect and team-level positive attitudes were observed in Phase 2 than in Scott's journals or in other phases of Shackleton's expedition. Furthermore, the second phase of Shackleton's expedition depicted the changing nature of the situation and a great deal of uncertainty, where positive aspects might be followed by sudden problems or issues—e.g., transitions like "enjoying the environment" → "negative affect" or "support behavior" → "problem encountered." In Shackleton's Phase 3, proportionally more problems and issues were extracted than before and although fewer positive aspects were connected to other variables than in the previous phase, several transitions related to the benefits of positive events/activities remained clear (e.g., "positive food experience" → "positive team climate" and "keeping goal in sight" → "positive affect"). These findings are consistent with the findings of several studies conducted in ICE contexts, informing on experiences that may mitigate or exacerbate different demands (Bell et al., 2019; Smith et al., 2018, 2019).

Besides the qualitative differences between the expeditions (e.g., Scott turning more to God during Phase 3 or Shackleton expressing more planning and proactive attitude

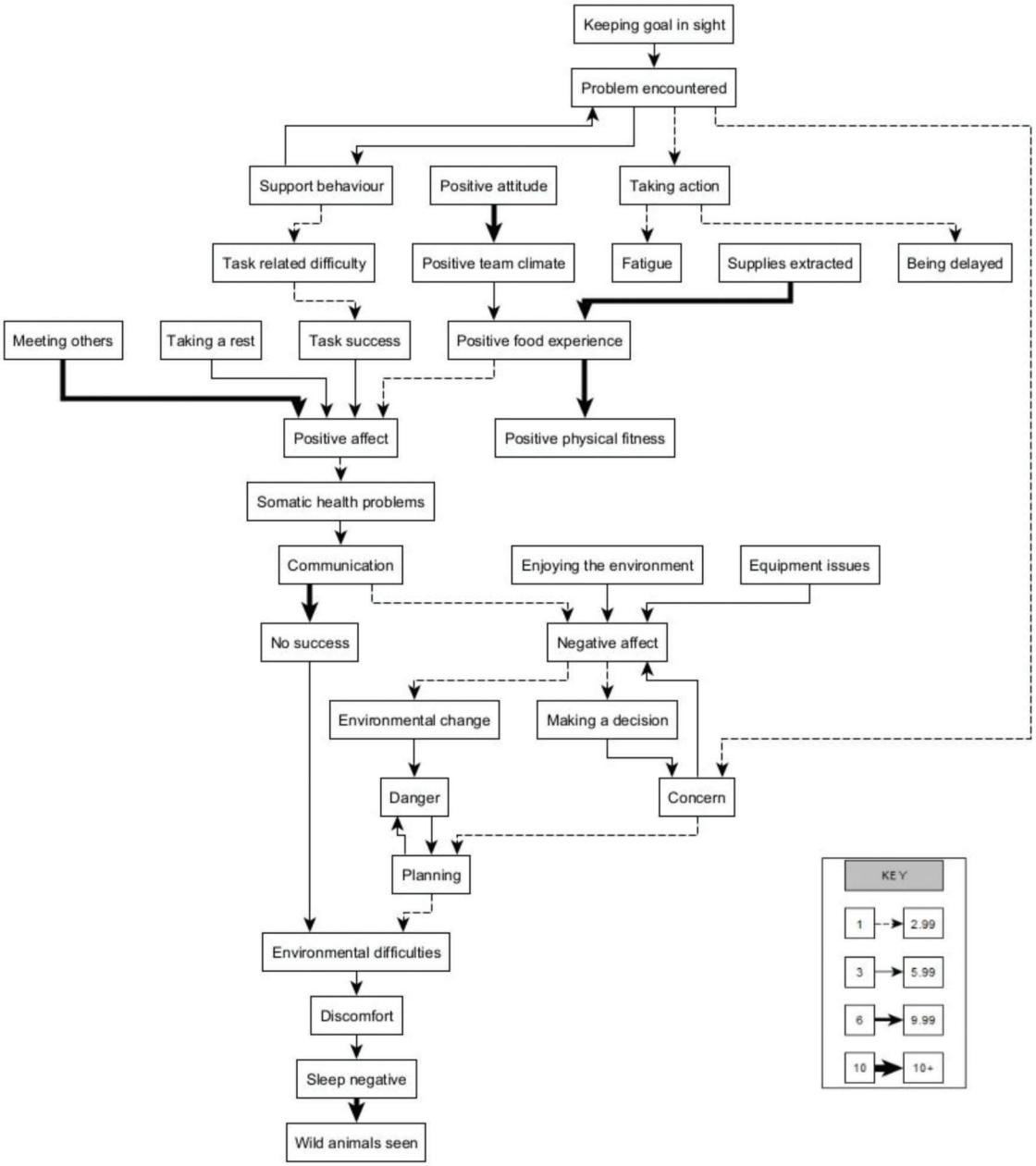

Figure 5. State transition diagram of Shackleton's expedition's Phase 2.

towards dealing with stressors while Scott expressed more "matter discussion"), it was apparent that, for Shackleton's expedition, there are fewer significant transitions and almost two times fewer lines of text and coded variables. One way to interpret this finding would be that in several periods of the expedition, Shackleton's crew dealt with acute and immediate dangers (e.g., rowing hundreds of miles across open ocean) so he had no convenient chance to journal (resulting in fewer source data). On the other hand, for most of the expedition the crew was in the same place, being rather inactive—this notion might lead to a hypothesis that instead of internal reflection and thinking about the dire situation, Shackleton was more active and spent less time on his own than did Scott. The result of these differences can be seen in the number of descriptions of the situation, but it is also possible that these differences speak of different leadership and communication styles and through that, are indicators of why the two expeditions had quite different endings.

Additionally, the current findings further replicate some of the findings from the literature review by Golden and colleagues (2018), also based on the IMOI model. Namely, that being exposed to colder temperatures reduces performance (as an input–output linkage, the environmental difficulties especially that Scott's team endured were often tied to low temperatures resulting in frostbite and reducing

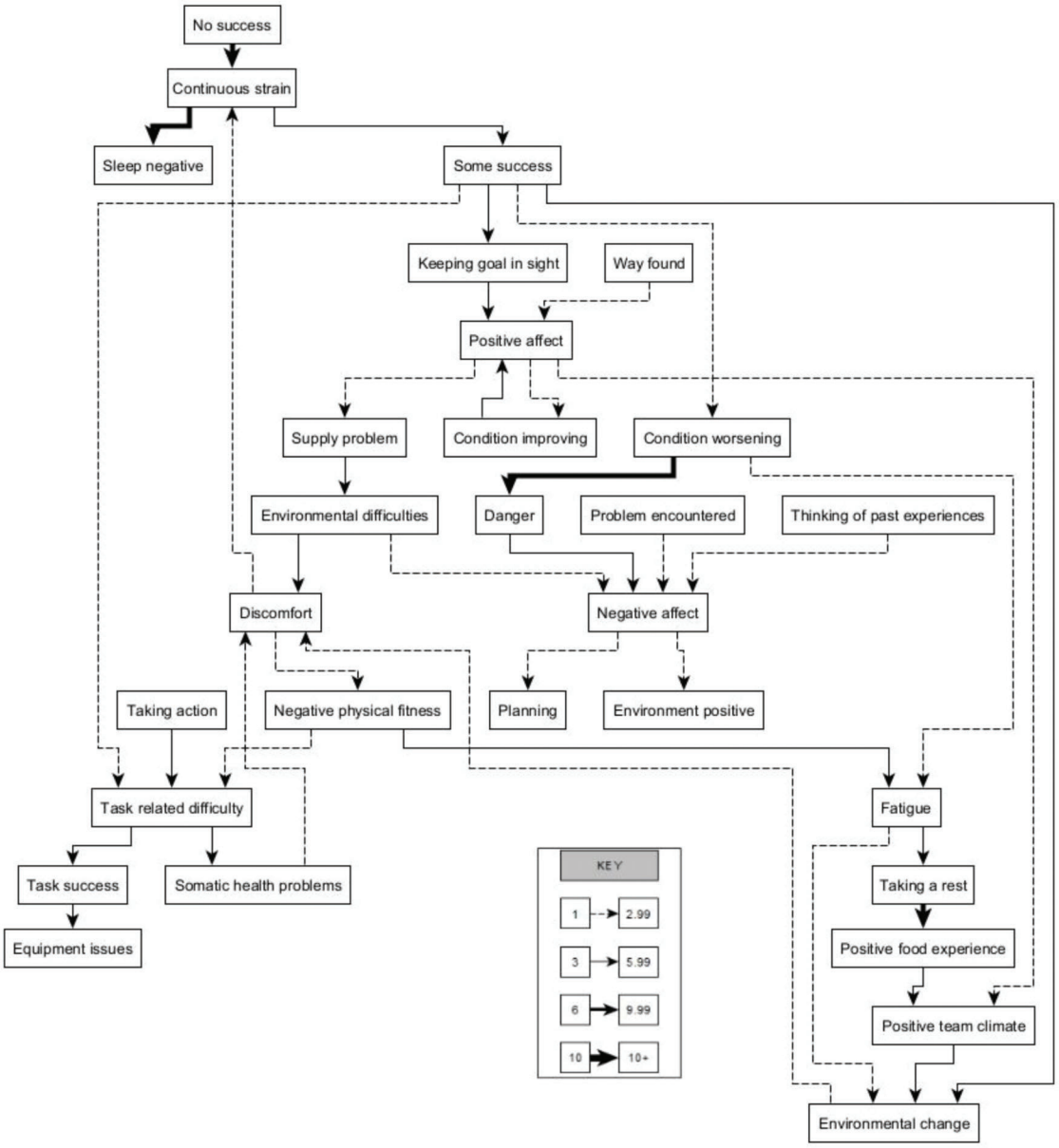

Figure 6. State transition diagram of Shackleton's expedition's Phase 3.

team performance; Solomon & Stearns, 1999) and negative affect impacts upon performance (as mediator–output linkage, Scott's transition diagrams were more associated with negative affect than Shackleton's, showing how the difficult conditions Scott's team endured acted as inputs to negative affect contributing to the unsuccessful expedition). Furthermore, the results indicate both the fluctuations in negative emotions and that the context of the expeditions (hereby time, the extent of being isolated, and environmental conditions), leadership style, and communication act as inputs for team performance, psychological well-being, and mission success, behavioral changes, usage of coping strategies, emotional states, and social climate acting as mediators, as Käosaar and colleagues (2022) have modelled in their review of team dynamics in ICE environments based on the IMOI framework.

The present findings also support the dynamic nature of communication and affect over time as reported by several other studies in other ICE settings (Bell et al., 2019; Smith et al., 2018)—over the three phases of both expeditions, different transitions associated with affect and communication were observed, showing how depending on the context and teams' immediate situation, teams' affective response and ways of interacting will likely change. Together, the present findings build on and extend understanding of how the interplay of environmental conditions and team states affect the fluctuations of team processes and emergent states over time (Uitdewilligen et al., 2018).

Finally, the fact that the BSA results are depicted as transitions between two variables allows researchers to detect the transitions between different inputs, mediators, and outputs following the logic of existing team models (Ilgen et al., 2005). The underlying notion of the IMOI model, and other related models, that different variables can act either as inputs, mediators, or outputs of team functioning at different times is supported by our findings. For example, the variable "no success" can be identified as an outcome of unsuccessful communication, mediated by difficult environmental conditions during Shackleton's crew's sea voyage to Elephant Island. On the other hand, in Phase 3 of Shackleton's expedition, "no success" can be identified as an input to the variable "continuous strain."

One of the particularly unique contributions of the present study was the longitudinal application of BSA methods to preexisting source material (historic expedition journals), which enabled the assessment of myriad different variables and their interconnections to understand how team dynamics unfold across ICE deployments. Based on the present work, BSA seems to be a strong methodological approach for analyzing the complex dynamics that underpin the function of teams in ICE settings. This opens up the potential to explore the vast swathes of preexisting expedition and exploration material and design new prospective studies with BSA in mind. Given the focus on identifying predictable transition sequences between events, behaviors, and outcomes, with further study, BSA has the potential to contribute to intricate team decision models that can be used to anticipate how situations might unfold and what countermeasures may be best implemented when teams are operating independently in ICE settings.

Limitations

There are two key limitations to note in this proof-of-concept research. First, the data source for this work consisted of only two historical expeditions. While this constituted a large volume of information, issues of generalization should be considered before applying findings to other ICE settings. That said, many of the transition sequences observed align with findings of prior ICE research and/or are consistent with preexisting theory. A second limitation is related to nature of the source material. Both journals are from the perspective of one person, the expedition leader. While the leader should have had an overall perspective of the expedition, their own tendencies and biases in how they recorded and communicated the expedition will have characterized some of the content, and thus shaped how the material was coded.

Future Directions

The current experimental research has shown the potency of BSA for analyzing qualitative data from ICE environments. For developing the method into a scalable and useful tool for polar stations, space organizations, and associated stakeholders, further research and development of the method are needed. The next steps would include applying the method on more conventional ICE settings (e.g., wintering polar stations, ISS crews, and space analog simulations [e.g., Mars-500 and HI-SEAS]) and potentially automating the coding process. During these steps, it would be possible to include ICE teams' representatives into the research to develop protocols for reporting the findings in a more practical manner.

In this work BSA was applied on journals of the leaders of historical polar expeditions. Although the focus was on specific events of interest in these journals, the scope of these events was quite broad. In the future, it might be beneficial to focus on a particular type of event in an ICE setting, e.g., accidents or near accidents on polar bases. The resulting BSA analysis and sequence diagrams could in that case be more focused on standard operating procedures, thus giving more practical outcomes for stakeholders.

Developments to the codebook may also be required to directly test elements of existing team models. To code in this way would require multiple sources of material from within the same team (intact team data).

In conclusion, findings from the current research suggest that BSA is a plausible method for analyzing journal data that might inform on the social psychology of teams in ICE settings. The results of this initial work are largely consistent with other intensive studies (daily, weekly, monthly assessments) of teams in ICE settings. The approach detailed potentially offers a new way of leveraging insight from existing abundant data, e.g., the personal journals of expeditioners. Going forward, additional research with a larger and more diverse pool of source data will help validate the method. In the future, outputs of this research could inform decision support systems that inform analysts on unfolding dynamics in ICE teams and potential ways of influencing and shaping a more positive experience for those team members.

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References

Bell, S. T., Brown, S. G., & Mitchell, T. (2019). What we know about team dynamics for long-distance space missions: A systematic review of analog research. *Frontiers in Psychology*, *10*, 811. https://doi.org/10.3389/fpsyg.2019.00811

Burke, C. S., Shuffler, M. L., & Wiese, C. W. (2018). Examining the behavioral and structural characteristics of team leadership in extreme environments. *Journal of Organizational Behavior*, *39*(6), 716–730. https://doi.org/10.1002/job.2290

Burke, C. S., Wiese, C. W., & Campbell, L. N. P. (2021). Leveraging historiometry to better understand teams in context. *Organizational Psychology Review*, *11*(3), 319–339. https://doi.org/10.1177/2041386621996424

Caldwell, B. S. (2006). Group performance and space flight teams. In C. Bowers, E. Salas, & F. Jentsch (Eds.), *Creating high-tech teams: Practical guidance on work performance and technology* (pp. 161–182). *American Psychological Association*. https://doi.org/10.1037/11263-008

Driskell, T., Salas, E., & Driskell, J. E. (2018). Teams in extreme environments: Alterations in team development and teamwork. *Human Resource Management Review*, *28*(4), 434–449. https://doi.org/10.1016/j.hrmr.2017.01.002

ESA. (2021). *ESA: The SciSpacE White Papers*. https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Research/The_SciSpacE_White_Papers

Fossi, J. J., Clarke, D. D., & Lawrence, C. (2005). Bedroom rape sequences of sexual behavior in stranger assaults. *Journal of Interpersonal Violence*, *20*(11), 1444–1466. https://doi.org/10.1177/0886260505278716

Golden, S. J., Chang, C. H. (Daisy), & Kozlowski, S. W. J. (2018). Teams in isolated, confined, and extreme (ICE) environments: Review and integration. *Journal of Organizational Behavior*, *39*(6), 701–715. https://doi.org/10.1002/job.2288

Gunderson, E. K. E. (2012). *From Antarctica to outer space: Life in isolation and confinement*. Springer Science & Business Media.

Ilgen, D. R., Hollenbeck, J. R., Johnson, M., & Jundt, D. (2005). Teams in organizations: From input-process-output models to IMOI models. *Annual Review of Psychology*, *56*(1), 517–543. https://doi.org/10.1146/annurev.psych.56.091103.070250

Kanas, N. (2014). Psychosocial issues during an expedition to Mars. *Acta Astronautica*, *103*, 73–80. https://doi.org/10.1016/j.actaastro.2014.06.026

Käosaar, A., Marques-Quinteiro, P., & Burke, S. (2022). Fantastic teams and where to find them: Understanding team processes in space and analog environments through the IMOI framework. *Team Performance Management*, *28*(3/4), 109–124. https://doi.org/10.1108/tpm-02-2021-0012

Kass, R., & Kass, J. (2001). Team-work during long-duration isolation. *52nd International Astronautical Congress*.

Keatley, D. A. (2018). Online behaviour lists: Sexual assaults and rape cases. In *Pathways in crime* (pp. 83–90). *Palgrave Macmillan. https://doi.org/10.1007/978-3-319-75226-6_6*

Keatley, D. A., & Clarke, D. D. (2020). Matrix forecasting and behaviour sequence analysis: Part of the timeline toolkit for criminal investigation. *Journal of Police and Criminal Psychology*, *37*(1), 1–8. https://doi.org/10.1007/S11896-020-09367-1

Kjaergaard, A., Leon, G. R., & Chterev, K. (2022). Team effectiveness and person-environment adaptation in an analog lunar habitat. *Aerospace Medicine and Human Performance*, *93*(2), 70–78. https://doi.org/10.3357/AMHP.5983.2022

Kjærgaard, A., Leon, G. R., & Fink, B. A. (2015). Personal challenges, communication processes, and team effectiveness in military special patrol teams operating in a polar environment. *Environment and Behavior*, *47*(6), 644–666. https://doi.org/10.1177/0013916513512834

Landon, L. B., Slack, K. J., & Barrett, J. D. (2018). Teamwork and collaboration in long-duration space missions: Going to extremes. *American Psychologist*, *73*(4), 563–575. https://doi.org/10.1037/amp0000260

Landon, L. B., Slack, K. J., & Salas, E. (2021). *Psychology and human performance in space programs*. CRC Press.

Leon, G. R., Sandal, G. M., & Larsen, E. (2011). Human performance in polar environments. *Journal of Environmental Psychology*, *31*(4), 353–360. https://doi.org/10.1016/J.JENVP.2011.08.001

Marono, A., Clarke, D. D., Navarro, J., & Keatley, D. A. (2017). A behaviour sequence analysis of nonverbal communication and deceit in different personality clusters. *Psychiatry, Psychology and Law*, *24*(5), 730–744. https://doi.org/10.1080/13218719.2017.1308783

Marono, A. J., Reid, S., Yaksic, E., & Keatley, D. A. (2020). A behaviour sequence analysis of serial killers' lives: From childhood abuse to methods of murder. *Psychiatry, Psychology and Law*, *27*(1), 126–137. https://doi.org/10.1080/13218719.2019.1695517

Mocellin, J. S. P., & Suedfeld, P. (1991). Voices from the ice: Diaries of polar explorers. *Environment and Behavior*, *23*(6), 704–722. https://doi.org/10.1177/0013916591236004

NASA HRP. (2015, July 30). Human research roadmap.

Palinkas, L. A. (2001). Psychosocial issues in long-term space flight: Overview. *Gravitational and Space Biology Bulletin*, *14*(2), 25–33.

Patel, Z. S., Brunstetter, T. J., Tarver, W. J., Whitmire, A. M., Zwart, S. R., Smith, S. M., & Huff, J. L. (2020). Red risks for a journey to the red planet: The highest priority human health risks for a mission to Mars. *Npj Microgravity*, *6*(33), 1–13. https://doi.org/10.1038/s41526-020-00124-6

Sandal, G. M., & Bye, H. H. (2015). Value diversity and crew relationships during a simulated space flight to Mars. *Acta Astronautica*, *114*, 164–173. https://doi.org/10.1016/j.actaastro.2015.05.004

Scott, R. F. (2005). *Journals: Captain Scott's last expedition* (M. Jones, Ed.). Oxford University Press.

Shackleton, E. (1919). *South: The story of Shackleton's last expedition*, 1914–1917. William Heinemann.

Smith, N., Barrett, E., & Sandal, G. M. (2018). Monitoring daily events, coping strategies, and emotion during a desert expedition in the Middle East. *Stress and Health*, *34*(4), 534–544. https://doi.org/10.1002/SMI.2814

Smith, N., Keatley, D., Sandal, G. M., Kjaergaard, A., Stoten, O., Facer-Childs, J., & Barrett, E. C. (2019). Relations between daily events, coping strategies and health during a British Army ski expedition across Antarctica. *Environment and Behavior*, *53*(1), 91–116. https://doi.org/10.1177/0013916519886367

Solomon, S., & Stearns, C. R. (1999). On the role of the weather in the deaths of R. F. Scott and his companions. *Proceedings of the National Academy of Sciences of the United States of America*, *96*(23), 13012–13016. https://doi.org/10.1073/pnas.96.23.13012

Stuster, J., Bachelard, C., & Suedfeld, P. (1999). *In the wake of the astrolabe: Review and analysis of diaries maintained by the leaders and physicians of French remote duty stations*.

Suedfeld, P. (2010). Historical space psychology: Early terrestrial explorations as Mars analogues. *Planetary and Space Science*, *58*(4), 639–645. https://doi.org/10.1016/J.PSS.2009.05.010

Suedfeld, P. (2018). Antarctica and space as psychosocial analogues. *REACH—Reviews in Human Space Exploration*, *9*, 1–4. https://doi.org/10.1016/j.reach.2018.11.001

Townsend, E., Wadman, R., Sayal, K., Armstrong, M., Harroe, C., Majumder, P., Vostanis, P., & Clarke, D. (2016). Uncovering key patterns in self-harm in adolescents: Sequence analysis using the Card Sort Task for Self-harm (CaTS). *Journal of Affective Disorders*, *206*, 161–168. https://doi.org/10.1016/J.JAD.2016.07.004

Uitdewilligen, S., Rico, R., & Waller, M. (2018). Fluid and stable: Dynamics of team action patterns and adaptive outcomes. *Journal of Organizational Behavior*, *39*(9), 1113–1128. https://doi.org/10.1002/job.2267

van Wijk, C. H., & Dalla Cia, V. (2016). *"Covert coping" in extreme environments: Insights from South African submarines*. *Journal of Human Performance in Extreme Environments*, *12*(2), Article 3. https://doi.org/10.7771/2327-2937.1083

Appendix A

Codebook

Original code	If recoded for degranulation, the new aggregated code	Aggregated new codes
Acceptance		Danger
Acknowledge of achievement		Taking action
Active distraction		Somatic health problems
Aggressive behavior others		Sleep negative
Aggressive behavior self		Sleep positive
Animal dead		Problem encountered
Animal ill		Task success
Animal saved		Supply problem
Animal still ill		Emotion sharing
Animals fighting	Problem encountered	Emotion regulation
Animals fine		Positive affect
Assertive behavior others		Negative affect
Assertive behavior self		Planning
Assertive communication		Positive team climate
Bad weather	Environmental difficulties	Negative team climate
Bad wind	Environmental difficulties	Concern
Behavioral changes negative		Resilient behavior
Behavioral changes positive		Support behavior
Being amused	Positive affect	Communication
Being annoyed	Negative affect	Task-related difficulty
Being concerned	Concern	Matter discussion
Being delayed		Equipment issues
Being glad	Positive affect	Equipment positive
Being nervous	Negative affect	Environmental difficulties
Being persistent	Resilient behavior	Environmental change
Being ready		Environment positive
Being scared		
Being thankful	Negative affect	
Bravery	Resilient behavior	
Call for patience	Negative affect	
Centered leadership		
Communication	Communication	
Communication problems		
Competition lost	Problem encountered	
Concerns for others		
Concerns of current weather	Concern	
Concerns of future	Concern	
Condition change	Environmental change	
Condition improving		
Condition worsening		
Confession of past fear	Emotion sharing	
Conflict with more than one person		
Conflict with one person		
Confrontational behavior others		
Confrontational behavior self		
Confusion	Concern	
Continuous strain		
Continuous work	Task-related difficulty	
Crew parting		
Crew singing	Positive team climate	
Danger from environment	Danger	
Danger to life	Danger	
Decision suggestion from others		
Difficult task	Task-related difficulty	
Diminishing supplies	Supply problem	
Discomfort		
Discuss emotions	Emotion sharing	
Discussing future positive scenario		

Continued

Appendix A
(Continued)

Original code	If recoded for degranulation, the new aggregated code	Aggregated new codes
Emergency		
Emotion regulation	Emotion regulation	
Emotional detachment		
Enjoying the environment		
Equipment damage	Equipment issues	
Equipment failure	Equipment issues	
Equipment fixed	Equipment positive	
Equipment found	Equipment positive	
Faith/religion		
Falling through ice	Problem encountered	
Fatigue		
Feeling bored		
Feeling connected		
Feeling desperate	Negative affect	
Feeling disappointed	Negative affect	
Feeling helpless	Negative affect	
Feeling lonely	Negative affect	
Feeling of anxiety	Negative affect	
Feeling of bad luck	Negative affect	
Feeling of comfort		
Feeling of confinement	Negative affect	
Feeling of fear	Negative affect	
Feeling of hope	Positive affect	
Feeling of hopelessness	Negative affect	
Feeling of impatience		
Feeling of irritation	Negative affect	
Feeling of isolation		
Feeling of luck	Positive affect	
Feeling of security	Positive affect	
Feeling sad	Negative affect	
Feeling safe	Positive affect	
Feeling stress		
Feeling supported		
Feelings about autonomy		
Food contamination		
Friendly bantering		
Future weather concerns	Concern	
Getting lost	Problem encountered	
Getting message from others	Communication	
Good conditions	Environment positive	
Good equipment	Equipment positive	
Good sleep quality	Sleep positive	
Good weather	Environment positive	
Good wind	Environment positive	
Habitat comfort		
Habitat difficulties		
Hard conditions	Environmental difficulties	
Helping others	Support behavior	
Hiding information		
High workload	Task-related difficulty	
Hint of danger	Danger	
Holiday		
Hygiene		
Inactivity		
Increased amount of sleep	Sleep positive	
Injury	Somatic health problems	
Jubilation	Positive team climate	
Keeping goal in sight		

Continued

Appendix A
(Continued)

Original code	If recoded for degranulation, the new aggregated code	Aggregated new codes
Lack of privacy		
Leadership negative		
Leadership positive		
Loss of equipment	Equipment issues	
Loss of mind		
Low workload		
Making a decision		
Meeting others		
Minor accident	Problem encountered	
Missing equipment	Equipment issues	
Missing home	Negative affect	
Mission success	Task success	
Monotony		
Mood change negative	Negative affect	
Mood change positive	Positive affect	
Negative affect	Negative affect	
Negative affect about others		
Negative affect about self		
Negative food experience		
Negative physical fitness		
Negative social interaction	Negative affect	
No communication		
No success		
No wild animals seen		
Not paying attention to danger		
Nutrition concern	Supply problem	
Organizing crew	Taking action	
Organizing gear	Taking action	
Past situation discussion	Matter discussion	
Past trauma hurts		
People avoidance		
Person saved		
Personal items for support		
Physical pain	Somatic health problems	
Physical violence		
Planning	Planning	
Positive affect about others		
Positive affect about self		
Positive attitude		
Positive feeling	Positive affect	
Positive food experience		
Positive physical fitness		
Positive reappraisal		
Positive social interaction	Positive affect	
Problem discussion	Matter discussion	
Problem encountered	Problem encountered	
Psychological well-being negative		
Psychological well-being positive		
Reduced amount of sleep	Sleep negative	
Reduced sleep quality	Sleep negative	
Relaxing oneself	Emotion regulation	
Repair/maintenance	Taking action	
Repetitive tasks	Task-related difficulty	
Rushing		
Securing the situation	Taking action	
Self-talk	Emotion regulation	
Sensational illusions		
Shared feelings	Emotion sharing	
Shared leadership		

Continued

Appendix A
(Continued)

Original code	If recoded for degranulation, the new aggregated code	Aggregated new codes
Ship sunk	Equipment issues	
Situation being bad	Problem encountered	
Situation evaluation	Planning	
Small problems	Problem encountered	
Social climate change negative		
Social climate change positive	Positive team climate	
Social climate negative	Negative team climate	
Social climate positive	Positive team climate	
Solving problem	Taking action	
Somatic health problems	Somatic health problems	
Some success		
Stuck in the habitat		
Stuck in the ice	Problem encountered	
Supplies extracted		
Support behavior	Support behavior	
Support seeking		
Suppressing emotions	Emotion regulation	
Taking a rest		
Taking care	Support behavior	
Task discussion	Matter discussion	
Task execution	Taking action	
Task success	Task success	
Team cohesion negative	Negative team climate	
Team cohesion positive	Positive team climate	
Team efficacy negative		
Team efficacy positive	Positive team climate	
Team member dead	Problem encountered	
Team performance negative	Negative team climate	
Team performance positive	Positive team climate	
Tension relief	Positive affect	
Tension rise	Negative affect	
Tension with others	Negative team climate	
Terrain difficulties	Environmental difficulties	
Thinking of past accident		
Thinking of past experiences		
Uncertainty	Concern	
Unexpected event	Problem encountered	
Use of humor	Positive team climate	
Use the situation for alternative activities		
Venting emotions others		
Venting emotions self	Emotion regulation	
Waiting		
Water overboard	Problem encountered	
Way found		
Weather change	Environmental change	
Weight gain		
Weight loss		
Wild animals seen		
Wish of support		

Note. Underlined original codes were not used during the coding.

Appendix B

Transitions for Scott's expedition

Antecedent	Sequitur	SR	*n*
Scott Phase 1			
Some success	Problem encountered	5.39	11
Taking action	Task-related difficulty	3.19	10
Planning	Taking action	2.84	9
Environmental change	Some success	3.57	8
Condition improving	Some success	4.53	7
Problem encountered	Negative affect	2.23	7
Task success	Positive affect	3.48	6
Problem encountered	Concern	2.77	6
Task-related difficulty	Some success	2.22	6
Some success	Task success	3.65	5
Environmental change	Concern	2.13	5
Equipment issues	Equipment issues	7.23	4
Positive affect	Use the situation for alternative activities	3.76	4
No success	Negative affect	3.32	4
Taking action	No success	2.81	4
Making a decision	Taking action	2.61	4
Wild animals seen	Positive affect	2.60	4
Positive affect	Positive team climate	2.18	4
Positive team climate	Positive affect	2.15	4
Environmental difficulties	Stuck in the habitat	8.85	3
Wild animals seen	Wild animals seen	5.74	3
Positive team climate	Positive team climate	4.54	3
Stuck in the habitat	Negative affect	4.34	3
Positive physical fitness	Positive affect	3.97	3
Environment positive	Environmental change	3.67	3
Condition worsening	Task-related difficulty	3.11	3
Animal dead	Negative affect	2.87	3
Environmental change	Danger	2.27	3
Problem encountered	Danger	2.22	3
Danger	Task-related difficulty	2.22	3
Task-related difficulty	Task success	2.11	3
Meeting others	Fatigue	11.68	2
Discomfort	Continuous strain	10.41	2
Use the situation for alternative activities	Positive physical fitness	8.43	2
Making a decision	Taking a rest	6.92	2
Matter discussion	Making a decision	6.27	2
Task-related difficulty	Resilient behavior	6.02	2
Negative affect	Positive reappraisal	4.83	2
Positive affect about others	Environmental difficulties	4.79	2
Positive affect	Emotion sharing	4.50	2
Danger	Animal dead	4.12	2
Taking action	Sleep negative	3.33	2
Positive team climate	Wild animals seen	3.23	2
Task success	Making a decision	3.15	2
Task-related difficulty	Fatigue	3.11	2
Task-related difficulty	Continuous strain	3.11	2
Positive affect	Positive food experience	2.89	2
Planning	Support behavior	2.89	2
Meeting others	Positive affect	2.87	2
Negative affect	Animal saved	2.69	2
Continuous strain	Negative affect	2.35	2
Keeping goal in sight	Taking action	2.31	2
Environmental change	Environment positive	2.17	2
Environment positive	Problem encountered	2.13	2
Positive affect	Equipment positive	2.13	2
Negative affect	Somatic health problems	2.07	2

Continued

Appendix B
(Continued)

Negative affect	Supply problem	2.07	2
Environmental difficulties	Condition improving	2.01	2
	M	3.81	3.48
	SD	2.11	2.15
Scott Phase 2			
Condition worsening	Task-related difficulty	6.32	11
Some success	Condition worsening	5.80	10
Environmental difficulties	Discomfort	8.32	7
Task-related difficulty	Fatigue	6.19	6
Negative affect	Negative affect	3.11	6
Environmental change	Task-related difficulty	2.59	6
Environmental change	Positive affect	2.06	6
Taking action	Being delayed	5.89	5
Equipment issues	Taking action	6.64	4
Positive affect about others	Positive affect	2.82	4
Condition improving	Some success	2.34	4
Environmental difficulties	Stuck in the habitat	7.15	3
Stuck in the habitat	Negative affect	5.82	3
Problem encountered	Negative affect	3.49	3
Keeping goal in sight	Concern	2.86	3
Positive affect	Environment positive	2.26	3
Holiday	Positive food experience	11.20	2
Habitat difficulties	Discomfort	8.58	2
Negative affect	Acceptance	4.52	2
Crew parting	Negative affect	4.44	2
Discussing future positive scenario	Positive affect	4.08	2
Condition improving	Environment positive	3.39	2
Monotony	Negative affect	2.85	2
Taking action	Concerns for others	2.73	2
Some success	Continuous strain	2.26	2
Some success	Equipment issues	2.26	2
Task-related difficulty	Equipment issues	2.18	2
	M	4.52	3.93
	SD	2.40	2.48
Scott Phase 3			
Environmental difficulties	Task-related difficulty	6.26	11
Way found	Positive affect	6.40	10
Condition worsening	Task-related difficulty	4.53	10
Condition improving	Some success	5.18	8
Some success	Condition worsening	4.01	8
Condition improving	Positive affect	3.38	8
Concern	Negative affect	2.57	8
Environment positive	Some success	5.94	7
Condition worsening	Problem encountered	5.21	7
Positive affect	Supply problem	2.86	7
Environmental difficulties	Discomfort	5.76	6
Supply problem	Concern	2.86	6
Task-related difficulty	Condition worsening	2.07	6
Somatic health problems	Somatic health problems	6.00	5
Task-related difficulty	Fatigue	4.24	5
Negative physical fitness	Negative affect	2.96	5
Somatic health problems	Concern	2.77	5
Positive affect	Environment positive	2.55	5
Condition worsening	Stuck in the habitat	5.61	4
Faith/religion	Condition worsening	3.51	4
Environmental change	Task-related difficulty	3.39	4
Negative affect	Discomfort	2.50	4
Positive food experience	Positive physical fitness	5.38	3
Support behavior	Negative physical fitness	5.18	3
Taking a rest	Positive food experience	4.70	3
Negative physical fitness	Concerns for others	4.58	3
Some success	Planning	3.37	3

Continued

Appendix B
(Continued)

Making a decision	Environmental difficulties	3.24	3
Positive team climate	Task-related difficulty	2.88	3
Taking action	Problem encountered	2.73	3
Making a decision	Condition worsening	2.66	3
Negative affect	Matter discussion	2.60	3
Problem encountered	Problem encountered	2.46	3
Concern	Positive physical fitness	2.34	3
Negative affect	Making a decision	2.32	3
Use the situation for alternative activities	Task success	11.03	2
Positive physical fitness	Past trauma hurts	7.39	2
Positive affect about others	Concerns for others	7.02	2
Condition improving	Feeling of comfort	6.04	2
Concerns for others	Support behavior	5.62	2
Sleep positive	Positive physical fitness	4.77	2
Past trauma hurts	Negative physical fitness	4.71	2
Taking action	Being delayed	4.25	2
Supply problem	Positive affect about others	4.14	2
Discomfort	Keeping goal in sight	3.91	2
Concern	Communication	3.89	2
Positive food experience	Positive team climate	3.84	2
Taking a rest	Environmental change	3.78	2
Sleep negative	Supply problem	3.76	2
Positive food experience	Sleep positive	3.61	2
Matter discussion	Making a decision	3.46	2
Positive physical fitness	Environment positive	3.42	2
Negative physical fitness	Support behavior	3.28	2
Faith/religion	Matter discussion	3.20	2
Negative team climate	Discomfort	3.19	2
Sleep positive	Taking action	3.19	2
Stuck in the habitat	Condition improving	3.13	2
Planning	Negative physical fitness	3.05	2
Positive physical fitness	Discomfort	3.01	2
Environmental difficulties	Stuck in the habitat	2.99	2
Planning	Supply problem	2.98	2
Way found	Taking a rest	2.94	2
Problem encountered	Negative team climate	2.94	2
Task-related difficulty	Continuous strain	2.91	2
Some success	Equipment positive	2.66	2
Problem encountered	Matter discussion	2.46	2
Positive food experience	Somatic health problems	2.21	2
Support behavior	Some success	2.19	2
Support behavior	Negative affect	2.19	2
Being delayed	Concern	2.14	2
Taking a rest	Condition improving	2.14	2
Keeping goal in sight	Task-related difficulty	2.03	2
Problem encountered	Way found	2.01	2
	M	3.79	3.53
	SD	1.57	2.29

Appendix C

Transitions for Shackleton's expedition

Antecedent	Sequitur	SR	*n*
Shackleton Phase 1			
Taking action	Task-related difficulty	2.88	6
Taking action	Task success	3.61	5
Negative affect	Planning	2.63	4
Taking action	No success	2.09	4
Planning	Danger	2.89	3
Condition improving	Taking action	2.41	3
Concern	Sleep negative	6.24	2
Danger	Person saved	5.97	2
Use the situation for alternative activities	Environmental change	4.42	2
Task-related difficulty	Some success	4.20	2
Task-related difficulty	Sleep negative	4.20	2
Task-related difficulty	Wild animals seen	3.66	2
Concern	Equipment issues	3.66	2
Wild animals seen	Danger	3.47	2
No success	Making a decision	3.25	2
Task success	Environmental change	3.11	2
Condition worsening	Equipment issues	3.03	2
Taking action	Being ready	2.93	2
Equipment issues	Equipment issues	2.58	2
Planning	Condition worsening	2.51	2
Condition worsening	Danger	2.51	2
Task-related difficulty	No success	2.44	2
Negative affect	Waiting	2.32	2
Waiting	Negative affect	2.32	2
Danger	Equipment issues	2.10	2
	M	3.26	2.52
	SD	1.08	1.08
Shackleton Phase 2			
Equipment issues	Negative affect	4.77	5
Environmental change	Danger	3.28	5
Negative affect	Environmental change	2.51	5
Environmental difficulties	Discomfort	5.90	4
Task success	Positive affect	4.71	4
Concern	Negative affect	3.29	4
Problem encountered	Taking action	2.08	4
Communication	No success	7.63	3
Meeting others	Positive affect	7.43	3
Planning	Danger	3.09	3
Danger	Planning	3.09	3
Taking action	Fatigue	2.45	3
Positive attitude	Positive team climate	7.75	2
Supplies extracted	Positive food experience	7.47	2
Sleep negative	Wild animals seen	7.22	2
Positive food experience	Positive physical fitness	6.39	2
Discomfort	Sleep negative	5.53	2
Keeping goal in sight	Problem encountered	5.36	2
Somatic health problems	Communication	5.30	2
Taking a rest	Positive affect	4.83	2
Positive team climate	Positive food experience	4.66	2
Enjoying the environment	Negative affect	4.48	2
No success	Environmental difficulties	3.40	2
Making a decision	Concern	3.21	2
Support behavior	Problem encountered	3.14	2
Problem encountered	Support behavior	3.14	2
Communication	Negative affect	2.58	2
Positive affect	Somatic health problems	2.56	2
Problem encountered	Concern	2.56	2
Taking action	Being delayed	2.52	2

Continued

Appendix C
(Continued)

Antecedent	Sequitur	SR	*n*
Negative affect	Making a decision	2.40	2
Planning	Environmental difficulties	2.37	2
Task-related difficulty	Task success	2.25	2
Positive food experience	Positive affect	2.15	2
Support behavior	Task-related difficulty	2.09	2
Concern	Planning	2.00	2
	M	4.04	2.61
	SD	1.85	0.99
Shackleton Phase 3			
Taking action	Task-related difficulty	3.60	7
Condition worsening	Danger	6.40	4
Danger	Negative affect	4.99	4
Task-related difficulty	Task success	4.14	4
Environmental difficulties	Discomfort	3.43	4
Taking a rest	Positive food experience	6.06	3
Positive food experience	Positive team climate	4.28	3
Condition improving	Positive affect	4.10	3
Positive team climate	Environmental change	4.00	3
Keeping goal in sight	Positive affect	3.75	3
Task-related difficulty	Somatic health problems	3.15	3
Problem encountered	Negative affect	2.89	3
Some success	Task-related difficulty	2.50	3
Positive affect	Positive team climate	2.17	3
Environmental difficulties	Negative affect	2.03	3
No success	Continuous strain	7.27	2
Continuous strain	Sleep negative	6.22	2
Some success	Keeping goal in sight	3.49	2
Task success	Equipment issues	3.40	2
Negative physical fitness	Fatigue	3.32	2
Continuous strain	Some success	3.24	2
Supply problem	Environmental difficulties	3.24	2
Fatigue	Taking a rest	3.07	2
Some success	Environmental change	3.01	2
Thinking of past experiences	Negative affect	2.91	2
Fatigue	Environmental change	2.85	2
Positive affect	Supply problem	2.82	2
Discomfort	Negative physical fitness	2.65	2
Positive affect	Condition improving	2.52	2
way found	Positive affect	2.52	2
Discomfort	Continuous strain	2.42	2
Somatic health problems	Discomfort	2.42	2
Some success	Condition worsening	2.36	2
Negative affect	Planning	2.36	2
Negative affect	Environment positive	2.36	2
Environmental change	Discomfort	2.23	2
Condition worsening	Fatigue	2.21	2
Negative physical fitness	Task-related difficulty	2.05	2
	M	3.38	2.61
	SD	1.29	1.00