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Time-dependent mood fluctuations in Antarctic personnel: a meta-analysis

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ABSTRACT. The third-quarter phenomenon is the dominant theoretical model to explain the psychological impacts of deployment in Antarctica on personnel. It posits that detrimental symptoms to functioning, such as negative mood, increase gradually throughout deployment and peak at the third-quarter point, regardless of overall deployment length. However, there is equivocal support for the model. The current meta-analysis included data from 21 studies (involving 1,826 participants) measuring negative mood during deployment to elucidate this discrepancy. Across studies analyses were conducted on three data types: stratified by month using repeated-measured all time points meta-analytic techniques and pre/post-deployment data for summer/winter deployment seasons. Our results did not support the proposed parameters of the third-quarter phenomenon, as negative mood did not peak at the third-quarter point (August/September) of deployment. Overall effect sizes indicated that negative mood was greater at baseline than the end of deployment for summer and winter deployment seasons. These findings have theoretical and practical implications and should be used to guide future research, assisting in the development and modification of pre-existing prevention and intervention programmes to improve well-being and functioning of personnel during Antarctic deployment.

Introduction

Antarctica is one of the most extreme and unusual environments (EUEs) on Earth (Suedfeld & Steel, 2000). A consistently documented psychological response to Antarctic deployment is termed the 'winter-over syndrome'. This syndrome is characterised by alterations in mood, irritability and hostility, increases in psychosomatic complaints, insomnia, fatigue, cognitive impairment and occurrences of mild hypnotic states termed 'long eye' or 'Antarctic stare', and has been described as having similar impacts on functioning as subclinical depression (Palinkas & Suedfeld, 2008). As there is no specific validated scale to measure the winter-over syndrome, research investigating its impacts on Antarctic personnel has used a wide range of clinically validated psychological scales with a common correlate of assessing mood. This has resulted in a body of literature investigating the impacts winter-over syndrome has on psychological functioning through assessing time-dependent fluctuations in mood (herein referred to as mood fluctuations) (Lilburne, 2005).

Despite consensus in research that these mood fluctuations do exist in Antarctic personnel during deployment, the pattern in which these fluctuations reportedly occur is mixed (Wilson, 2011). The most commonly used theoretical paradigm to study the winter-over syndrome is the 'third-quarter phenomenon'. The third-quarter phenomenon was formally proposed by Bechtel and Berning (1991) who undertook a narrative review and identified that across extreme environments a similar pattern of mood fluctuation existed, reaching its lowest point around the three-quarter mark of the total mission duration (Connors, Harrison, & Akins, 1985; Kanas & Fedderson, 1971). Based on this review, the third-quarter phenomenon was defined as a period of distress, which occurs during the third-quarter of a fixed term of isolation, regardless of length (Bechtel & Berning, 1991).

As the third-quarter phenomenon has been proposed to occur in fixed-term situations of isolation and stress, Antarctica is an optimal environment to study this phenomenon. The winter deployment period (March to October) has been predominately utilised when investigating the third-quarter phenomenon in Antarctica, arguably due to greater challenges to the adaptation and functioning of personnel in comparison to the summer deployment period. The challenges include a significantly smaller population of personnel on the research bases with whom to interact, and more extreme weather conditions, temperatures and light/dark cycles (AAD, 2015a). To be consistent with the definition of the third-quarter phenomenon, a significant increase in negative mood would need to be identified in August/September, as this would be the third-quarter point of winter deployment periods. However, there is discrepancy in the literature surrounding if mood fluctuations occur in the pattern outlined by the third-quarter phenomenon (Shea, Slack, Keeton, Palinkas, & Leveton, 2011), which brings into question the validity of the third-quarter phenomenon as the dominant theoretical model to investigate the winter-over syndrome in Antarctic personnel during deployment.

Several studies have demonstrated support for the third-quarter phenomenon in Antarctic personnel. Steel (2001) observed a rise in negative mood, including anger, depression and confusion, in the third-quarter of expedition length, persisting until the end of deployment in nine winter personnel located at the New Zealand Antarctic base. These findings are consistent with the critical phases proposed by Bechtel and Berning (1991) and suggest the third-quarter phenomenon can be identified in personnel deployed Antarctica.

Palinkas, Gunderson, Johnson, and Holland (1999) also concluded the mood fluctuations observed in an American cohort wintering-over in Antarctica supported the existence of the third-quarter phenomenon. However, as these results showed a significant increase in mood disturbance scores during the second half of winter, in contrast to the first half of winter, these findings are instead inconsistent with the parameters of the third-quarter phenomenon (Barbarito, Baldanza, & Peri, 2001). Mood fluctuations inconsistent with the parameters of the third-quarter phenomenon were also found by Barbarito et al. (2001), whom reported significant mental disengagement and a reduction in coping skills at the mid-point of an expedition of nine Argentine men wintering in Antarctica. Likewise, Nicolas, Suedfeld, Weiss, and Gaudino (2016) observed mood fluctuations occurring outside the proposed parameters of the third-quarter phenomenon, as distress ratings in winter personnel from France and Italy peaked at the fourth quarter of deployment. These discrepancies in research surrounding mood fluctuations in Antarctic personnel necessitate further research to elucidate which point, if any, during Antarctic deployment poses the greatest detriment to psychological functioning.

The disparity in findings surrounding whether mood fluctuations are consistent with the third-quarter phenomenon is not the only inconsistency in literature surrounding the impact of Antarctic deployment on psychological functioning. Discrepancies surrounding whether Antarctic deployment has an overall negative impact on psychological functioning are also apparent. Whilst some studies have suggested that psychological health deteriorates across deployment (for example, Palinkas & Browner, 1995; Palinkas, Houseal, & Rosenthal, 1996), several others have failed to observe a detrimental impact of Antarctic deployment on the psychological functioning of personnel. Xu et al. (2003) did not identify any significant differences in mood in ten Chinese personnel between the beginning and end of the winter deployment period. Likewise, Weiss, Suedfeld, Steel, and Tanaka (2000) identified no detrimental change in mood between pre- and post-deployment across three crews, totalling 107 personnel, posted at Japan's Asuka Station during winter. This discrepancy in findings brings into question whether Antarctic deployment has a detrimental impact on the psychological functioning of Antarctic personnel.

Several potential explanations for the discrepancy in research findings have been proposed. From a methodological perspective, research investigating mood fluctuations in Antarctic personnel can be identified as being heavily influenced by Bechtel and Berning's (1991) proposed third-quarter phenomenon, with researchers analysing and reporting data in quarter averages or only collecting data at the end of each quarter (Wilson, 2011). This represents a significant confound as it increases the likelihood of finding quarterly effects by obscuring results and can lead to significant misinterpretation of the data (Rogelberg, 2008).

A second explanation for the inconsistency in research could be linked to the small sample sizes in studies, which has repeatedly been reported as a methodological limitation in research investigating Antarctic populations (Bhargava, Mukerji, & Sachdeva, 2000; Ikegawa, Kimura, Makita, & Itokawa, 1998; Johnson, Boster, & Palinkas, 2003), particularly during the winter deployment period. During the winter deployment period approximately 250 personnel are present across the 41 research bases that are considered to have a permanent, year-round, open status. This small population of potential participants is impacted further by research requiring voluntary consent to participate, as on average in research including human subjects only 3–20% of the eligible participant population consent to participate in studies (Monette, Sullivan, & DeJong, 2013). Small sample sizes result in studies having low statistical power which negatively impacts the probability that a nominally statistically significant finding reflects a true effect, as the estimated magnitude of the effect in a low power study is likely to be exaggerated, also minimising the probability of finding a true effect if one exists (Button et al., 2013), and detrimentally impacting the validity of the research conclusions.

Given the discrepancy in results and methodological limitations of existing research, it is difficult to ascertain the critical phases of mood fluctuations in Antarctic personnel. The identification of any critical phases of mood fluctuations and the clarification of the overall psychological impact of deployment on Antarctic personnel would have significant utility in the development of proactive prevention strategies and targeted interventions to maximise psychological functioning and work productivity during deployment in Antarctica (Norris, Paton, & Ayton, 2010; Zimmer, Cabral, Borges, Côco, & Hameister, 2013).

Shea et al. (2011) suggested that the employment of a meta-analytic technique to synthesise existing empirical research would offer a more complete understanding of the data, as the accumulation of data for stand-alone studies in Antarctic research is slow and sparse due to the inherent characteristics of Antarctic deployment (Zimmer et al., 2013). A meta-analysis can be identified as holding utility for the dispersed nature of data collected in Antarctic research because meta-analyses by nature address broader questions than individual studies, and thus can assess and compare the consistency, and hence generalisability, of findings between research articles (Borenstein, Hedges, Higgins, & Rothstein, 2009). To date this has not occurred. Therefore, the present study aimed to systematically review existing literature investigating mood fluctuations in Antarctic personnel and use meta-analytic techniques to attempt to answer the following research questions:

- Are mood fluctuations in Antarctic personnel consistent with the proposed parameters of the 'third-quarter phenomenon' when available data are analysed in monthly intervals?

- Once the methodological limitation of small sample sizes is removed, can an overall negative impact on psychological functioning in Antarctic personnel be universally identified?

Methods

Literature search, inclusion criteria and study selection

This systematic meta-analytic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009)

A multiple electronic database search was conducted using Scopus, Web of Science, PubMed and ProQuest using the following search strings selected on the basis of theoretical relevance: (1) 'cold climate' or 'Antarctic regions' or 'isolated, confined environment (ICE)' or 'extreme environment'; and (2) 'adverse effects' or 'human' or 'social isolation' or 'seasonal variation' or 'behavioural change' or 'adaptation' or 'interpersonal relations' or 'time factors' or 'stress reactions' or 'mood'; and (3) 'polar work' or 'research personnel' or 'expedition' or 'polar psychology' or 'psychology'; and (4) 'third-quarter phenomenon' or 'winter-over syndrome' or 'winter-over' or 'toast' or 'long eye' or 'hundred-foot stare' or 'big eye' or 'Antarctic stare'.

Studies were eligible for inclusion in the present review if they met the following inclusion criteria: (1) participants were Antarctic personnel; (2) assessment of negative mood was recorded; (3) data consisted of a numerical finding, including means, standard deviations and numerical tables of results. Studies were excluded if they: (1) were focused on populations outside of Antarctica (that is, Arctic and subpolar regions); (2) were published as popular media; (3) were a secondary analysis of data already identified in other included studies; or (4) recorded and reported an insufficient amount of data points to allow comparison (fewer than two).

An initial search yielded 2,563 articles, with duplicates removed 2,450 articles remained in the analysis. Applying the inclusion criteria, titles and abstracts were screened resulting in 2,405 articles being excluded from the review. Full texts for the remaining 45 studies were reviewed. A further 18 were excluded on the basis of the exclusion criteria. A manual search of the reference lists of articles which met the inclusion criteria was conducted to ensure relevant articles were not missed, resulting in a further eight articles being identified. Fourteen articles contain complete descriptive statistical information. Sixteen authors were contacted for missing descriptive statistical information in 21 articles, with seven authors supplying appropriate data for the analysis. As a result, 21 articles were identified and eligible for analysis (Supplementary Fig. 1).

Analysis

All analyses were conducted using a random-effects statistical model in Comprehensive Meta-Analysis Version 2.2 (Borenstein, Hedges, Higgins, & Rothstein, 2010). Where possible, descriptive statistical data were used; however, inferential data were incorporated when descriptive statistics were not available, as indicated in Tables 1–4. Due to the use of different measurement scales across studies, a matched Cohen's d was calculated as a standardised unit of effect size with 95% confidence intervals (CI), to convert results from individual studies to a uniform scale. As primary articles which reported descriptive statistics included in the current analysis did not report the pre–post correlation, $r = 0.50$ for all studies was assumed, after conducting a sensitivity analysis using the following plausible correlation ranges: $r = 0.25$, $r = 0.50$ and $r = 0.75$ (Supplementary Tables 1–3). The sensitivity analysis revealed an inconsequential change between the pre–post correlation values, as indicated by less than 20% difference between effect size estimates, which has been used in other matched groups meta-analyses (Del Re, Maisel, Blodgett, Wilbourne, & Finney, 2013; Young et al., 2015).

Due to the inherent methodological limitations of small populations in Antarctic research, a majority of the articles meeting the inclusion criteria had small sample sizes. To reduce the impact of the small sample sizes of included articles, weighted effects sizes were calculated to reduce any potential bias in the outcomes (Borenstein et al., 2010). For research articles that reported results for multiple constructs or subscales measuring negative mood (for example, depression, hostility and anxiety) in the same group of participants, a composite effect size for the study was computed (Supplementary Tables 4–6).

To examine heterogeneity between studies, Q and the I^2 statistics were calculated. Publication bias was assessed using the 'trim and fill' method by Duval and Tweedie (2000). In addition, subsequent cumulative meta-analyses were conducted to investigate if a positive drift could be identified as primary articles with small sample sizes were added to the analysis (McDaniel, 2009).

Units of analysis and datasets

Following a review of the studies that met the inclusion criteria, several common data collection and reporting methods across articles were identified: monthly, quarterly, and baseline and conclusion of summer and winter deployments. Based on this classification, four separate meta-analyses were run to allow clearer inferences to be made about the research questions and because the differences in data collection methods were not directly comparable.

To investigate research question 1, articles that assessed mood monthly were analysed using a repeated-measures all time points meta-analysis, with the non-temporal independence within the analyses taken into consideration via the inclusion of the pre–post correlation of $r = 0.50$. Due to the variety of analyses utilised in primary research articles, two separate repeated-measures all time points meta-analyses were conducted. The first analysis (analysis 1) compared the monthly measures of negative mood to a baseline measure, operationalised

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Table 1. Studies included in analysis 1.

Author	Year of publication	Year of data collection	Sample size	Sex	Deployment season	Research station	Nationality	Cultural orientation	Sample population	Negative mood scale	Type of publication	Statistics use in meta-analysis
Norris	2010	2005—2009	338	72% male	Winter-over		Australian	I		Hopkins Symptom Checklist (21 item version): General Distress subscale	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Oliver	1991	1977	31		Winter-over	McMurdo	American	I	Military Scientific Logistical support	Winter Over Status Questionnaire	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Palinkas & Houseal	2000b	1991	18	78% male	Winter-over	South Pole	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Standardised unit of measurement (Cohen's *d*)
Palinkas & Houseal	2000a	1991	62	76% male	Winter-over	McMurdo	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Standardised unit of measurement (Cohen's *d*)
Steel	2001		9		Winter-over	Scott Base	New Zealander	I		Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss & Gaud	2004		32	100% male	Winter-over	Dumont-d'Urville	French	I	Scientific Logistical support	Negative Polarity of Journal Entries	Journal article	Descriptive statistics (mean ± SD, sample size)

I = individualistic; SD = standard deviation.

Table 2. Studies included in analysis 2.

Author	Year of publication	Year of data collection	Sample size	Sex	Deployment season	Research station	Nationality	Cultural orientation	Sample population	Negative mood scale	Type of publication	Statistics use in meta-analysis
Norris	2010	2005–2009	333	72% male	Winter-over	Casey, Davis, Mawson	Australian	I	Scientific Logistical support	Hopkins Symptom Checklist (21 item version): General Distress Subscale	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Oliver	1991	1977	31		Winter-over	McMurdo	American	I	Military Scientific Logistical support	Winter Over Status Questionnaire	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Palinkas & Houseal	2000a	1991	18	78% male	Winter-over	South Pole	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Palinkas & Houseal	2000b		62	76% male	Winter-over	McMurdo	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Palinkas & Houseal	2000c		8		Winter-Over	Palmer	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Steel	2001		9		Winter-over	Scott Base	New Zealander	I		Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss & Gaud	2004		32	100%	Winter-over	Dumont-d'Urville	French	I	Scientific Logistical support	Negative Polarity Journal Entries	Journal article	Descriptive statistics (mean ± SD, sample size)

I = individualistic; SD = standard deviation.

Table 3. Studies included in analysis 3.

Author	Year of publication	Year of data collection	Sample Size	Sex	Deployment season	Research station	Nationality	Cultural orientation	Sample population	Negative mood scale	Type of publication	Statistics use in meta-analysis
Khandelwal, Bhatia, & Mishra	2015	2007–2008	33	100% male	Summer	Maitri	Indian	C		General Health Questionnaire: Composite Score of Anxiety and Insomnia and Depression Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Norris	2010	2005–2009		72% male	Summer	Casey, Davis, Mawson	Australian	I	Scientific Logistical support	Hopkins Symptom Checklist (21 item version): General Distress Subscale	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Peri, Scarlata, & Barbarito	2000		11	100% male	Summer	Terra Nova Bay	Italian	I	Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Steel	2001		9		Summer	Scott Base	New Zealander	I		Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Ursin et al.	1991	1989–1990	20	100% male	Summer		Norwegian	I	Scientific Logistical support	State-Trait Anxiety Inventory: State Anxiety Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)

I = individualistic; C = collectivist; SD = standard deviation.

Table 4. Studies included in analysis 4.

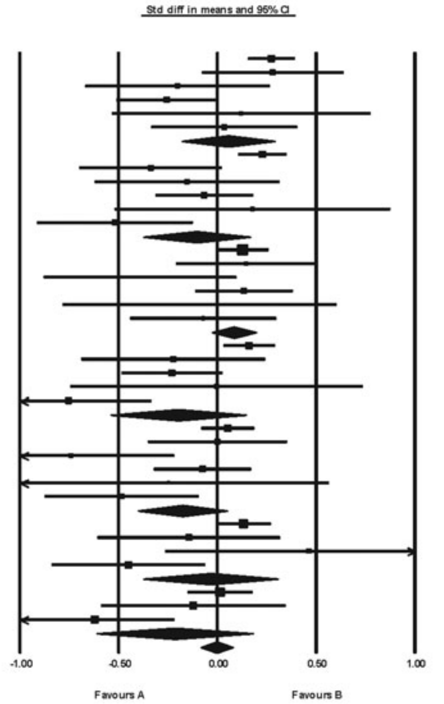
Author	Year of publication	Year of data collection	Sample size	Sex	Deployment season	Research station	Nationality	Cultural orientation	Sample population	Negative mood scale	Type of publication	Statistics use in meta-analysis
Barbarito et al.	2001	1998	9	100% male	Winter-over	Belgrano II	Argentine	C	Scientific Logistical support	COPE Inventory: Focusing on and Venting Emotion Subscale	Journal article	Descriptive and inferential statistics (mean, SD, sample size, *P* value)
Bhargava et al.	2000	1992–1993	25	100% male	Winter-over	Maitri	Indian	C	Scientific Logistical support	Satisfaction with work and life situations	Journal article	Descriptive and inferential statistics (sample size, frequencies, F statistic and *P* value)
Chen et al.	2016a	2003	12	100% male	Winter-over	Great Wall	Chinese	C	Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Chen et al.	2016b	2003	16	100% male	Winter-over	Zhongshan	Chinese	C	Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Harris et al.	2010	1999–2007	55	89% male	Winter-over	Rothera, Halley	British	I	Scientific Logistical support	Pseudoneurological Complaints of Depression and Anxiety	Journal article	Descriptive statistics (mean ± SD, sample size)
Ikegawa et al.	1998	1990–1992	8	100% male	Winter-over	Asuka	Japanese	C	Scientific Logistical support	Anxiety Sensitivity Index	Journal article	Descriptive statistics (mean ± SD, sample size)
McCormick, Taylor, Rivolier, & Cazes	1985		11		Winter-over		Mixed (Argentine, Australian, New Zealander, British, French)		Scientific Logistical support	Hopkins Symptoms Checklist: Total Distress Score	Journal article	Descriptive statistics (mean ± SD, sample size)
Mocellin et al.	2000		13	100% male	Winter-over	Marambio, Esperanza	Argentine	C	Military	State-Trait Anxiety Inventory: State Anxiety Subscale	Journal article	Inferential statistics (sample size, T statistic, df1, *P* value)
Nicolas et al.	2016		14	93% male	Winter-over	Concordia	French and Italian	I	Scientific Logistical Support	Total Stress Score of the Recovery Stress Questionnaire	Journal article	Descriptive and inferential statistics (mean, sample size, *P* value)

Table 4. Continued

Author	Year of publication	Year of data collection	Sample size	Sex	Deployment season	Research station	Nationality	Cultural orientation	Sample population	Negative mood scale	Type of publication	Statistics use in meta-analysis
Norris	2010	2005–2009	423	72% male	Winter-over	Casey, Davis, Mawson	Australian	I	Scientific Logistical support	Hopkins Symptom Checklist (21 item version): General Distress subscale	PhD thesis	Descriptive statistics (mean ± SD, sample size)
Palinkas & Browner	1995	1988–1989	91	84.30% male	Winter-over		American	I	Military Scientific Logistical support	Research Diagnostic Criteria	Journal article	Descriptive statistics (mean ± SD, sample size)
Palinkas & Browner	1995	1988–1989	89	84% male	Winter-over	McMurdo, Amundsen–Scott, Palmer	American	I	Military Scientific Logistical support	Research Diagnostic Criteria: Global Depressive Symptom Score	Journal article	Descriptive statistics (mean ± SD, sample size)
Palinkas et al.	1996	1990	67	100% male	Winter-over	Palmer, South Pole, McMurdo	American	I	Military Scientific Logistical support	21 item Hamilton Depression Rating Scale	Journal article	Descriptive statistics (mean ± SD, sample size)
Palinkas	1991	1988–1989	155		Winter-over	McMurdo	American	I	Military Scientific Logistical support	Research Diagnostic Criteria	Journal article	Descriptive statistic (correlation, sample size)
Palinkas & Houseal	2000	1991	87	78% male	Winter-over	South Pole, McMurdo, Palmer	American	I	Military Scientific Logistical support	Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Steel	2001		9		Winter-over	Scott Base	New Zealander	I		Profile of Mood States Scale: Composite Score of the Total Mood Disturbance Subscale	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss et al.	2004		32	100% male	Winter-over	Dumont-d'Urville	French	I	Scientific Logistical support	Negative Polarity Journal Entries	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss et al.	2000a	1991	31	100% male	Winter-over	Asuka	Japanese	C	Scientific Logistical support	Anxiety Sensitivity Index	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss et al.	2000b	1992	36	100% male	Winter-over	Asuka	Japanese	C	Scientific Logistical support	Anxiety Sensitivity Index	Journal article	Descriptive statistics (mean ± SD, sample size)
Weiss et al.	2000c	1993	40	100% male	Winter-over	Asuka	Japanese	C	Scientific Logistical support	Anxiety Sensitivity Index	Journal article	Descriptive statistics (mean ± SD, sample size)

I = individualistic; C = collectivist; SD = standard deviation; df1 = degrees of freedom 1.

Group by Time point	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
March-April	Norris, 2010	0.27	0.06	0.00	0.15	0.39	4.49	0.00	25.20
March-April	Oliver, 1991	0.28	0.18	0.03	-0.08	0.64	1.53	0.13	16.54
March-April	Palinkas et al., 2000a	-0.20	0.24	0.06	-0.67	0.27	-0.85	0.40	13.01
March-April	Palinkas et al., 2000b	-0.26	0.13	0.02	-0.51	-0.00	-1.96	0.05	20.43
March-April	Steel, 2001	0.12	0.33	0.11	-0.54	0.78	0.36	0.72	8.68
March-April	Weiss et al., 2004	0.03	0.19	0.04	-0.34	0.41	0.18	0.85	16.13
March-April		0.05	0.12	0.01	-0.18	0.29	0.44	0.66	
March-May	Norris, 2010	0.23	0.06	0.00	0.10	0.35	3.62	0.00	23.29
March-May	Oliver, 1991	-0.34	0.18	0.03	-0.70	0.02	-1.83	0.07	16.99
March-May	Palinkas et al., 2000a	-0.15	0.24	0.06	-0.62	0.31	-0.65	0.52	14.09
March-May	Palinkas et al., 2000b	-0.07	0.13	0.02	-0.31	0.18	-0.53	0.60	20.29
March-May	Steel, 2001	0.18	0.36	0.13	-0.52	0.88	0.50	0.62	9.27
March-May	Weiss et al., 2004	-0.52	0.20	0.04	-0.91	-0.12	-2.58	0.01	16.06
March-May		-0.11	0.14	0.02	-0.38	0.16	-0.78	0.44	
March-June	Norris, 2010	0.13	0.07	0.00	-0.00	0.26	1.91	0.06	55.65
March-June	Oliver, 1991	0.14	0.18	0.03	-0.21	0.50	0.80	0.42	9.48
March-June	Palinkas et al., 2000a	-0.39	0.25	0.06	-0.88	0.10	-1.57	0.12	5.07
March-June	Palinkas et al., 2000b	0.13	0.13	0.02	-0.11	0.38	1.06	0.29	18.61
March-June	Steel, 2001	-0.09	0.35	0.13	-0.78	0.60	-0.25	0.80	2.53
March-June	Weiss et al., 2004	-0.07	0.19	0.04	-0.44	0.30	-0.38	0.70	8.66
March-June		0.08	0.06	0.00	-0.03	0.19	1.44	0.15	
March-July	Norris, 2010	0.16	0.07	0.00	0.03	0.29	2.39	0.02	26.46
March-July	Palinkas et al., 2000a	-0.22	0.24	0.06	-0.69	0.24	-0.94	0.35	18.17
March-July	Palinkas et al., 2000b	-0.23	0.13	0.02	-0.49	0.03	-1.76	0.08	23.87
March-July	Steel, 2001	-0.00	0.38	0.14	-0.74	0.74	-0.01	0.99	12.02
March-July	Weiss et al., 2004	-0.75	0.21	0.05	-1.17	-0.33	-3.52	0.00	19.47
March-July		-0.20	0.17	0.03	-0.54	0.14	-1.15	0.25	
March-August	Norris, 2010	0.05	0.07	0.00	-0.08	0.19	0.76	0.44	27.19
March-August	Oliver, 1991	0.00	0.18	0.03	-0.35	0.35	0.00	1.00	17.35
March-August	Palinkas et al., 2000a	-0.74	0.27	0.07	-1.26	-0.22	-2.78	0.01	11.50
March-August	Palinkas et al., 2000b	-0.08	0.13	0.02	-0.32	0.17	-0.59	0.55	22.07
March-August	Steel, 2001	-0.25	0.41	0.17	-1.06	0.56	-0.60	0.55	6.13
March-August	Weiss et al., 2004	-0.48	0.20	0.04	-0.88	-0.09	-2.43	0.02	15.77
March-August		-0.18	0.11	0.01	-0.40	0.05	-1.56	0.12	
March-September	Norris, 2010	0.13	0.07	0.01	-0.01	0.27	1.86	0.06	37.13
March-September	Palinkas et al., 2000a	-0.15	0.24	0.06	-0.61	0.32	-0.61	0.54	22.78
March-September	Steel, 2001	0.46	0.37	0.14	-0.27	1.19	1.25	0.21	14.02
March-September	Weiss et al., 2004	-0.45	0.20	0.04	-0.84	-0.06	-2.27	0.02	26.08
March-September		-0.04	0.17	0.03	-0.38	0.30	-0.21	0.83	
March-October	Norris, 2010	0.01	0.08	0.01	-0.15	0.18	0.16	0.87	41.76
March-October	Palinkas et al., 2000a	-0.12	0.24	0.06	-0.59	0.35	-0.51	0.61	27.62
March-October	Weiss et al., 2004	-0.62	0.21	0.04	-1.03	-0.22	-3.01	0.00	30.62
March-October		-0.22	0.20	0.04	-0.61	0.18	-1.08	0.28	
Overall		-0.01	0.04	0.00	-0.09	0.07	-0.13	0.89	



Meta Analysis

Fig. 1. Forest plot for analysis 1.

as the first month of the winter deployment period. The second analysis (analysis 2) progressively compared monthly measures of negative mood to the month prior in the winter deployment period.

Two separate analyses were also conducted to assess research question 2 for data collected over the summer deployment and winter deployment periods. Separate analyses for summer (analysis 3) and winter deployments (analysis 4) were necessary due to the contrasting characteristics of these respective deployment seasons, such as deployment length (3–5 months during the summer, in contrast to 8–10 months during the winter), population size on the research bases, and differences in environmental characteristics including weather conditions, temperature and light/day cycles (AAD, 2015a). As analyses 3 and 4 only assessed two time points (baseline and end of deployment measures of negative mood), standard meta-analytic methods were utilised to produce a single summary effect (Peters & Mengersen, 2008). Allocation of research articles to the respective analysis based on data collection and reporting methods is outlined in Tables 1–4.

Where possible, data collected in different years or at different research bases were analysed separately. This is because group dynamics including crew tension and cohesion, as well as leadership dynamics on a research base, have been identified as being one of the greatest sources of stress in Antarctica (Stuster, Bachelard, & Suedfeld, 2000); thus, analysing data by research base and deployment year, where possible, minimises a potential loss of information.

Results

Analysis 1

Analysis 1 investigated research question 1 using a repeated time point meta-analysis, which compared monthly measurements of negative mood to a baseline, operationalised as the first month of deployment during the winter-over period (March). The characteristics of the included studies are listed in Table 1. Compared to March, negative mood was higher during May, July, August, September and October. Compared to March, negative mood was lower in April and June. No significant difference between March and any other month during the winter was identified, with all effect sizes trivial, except for March–July and March–October where a small effect size was identified (Fig. 1).

Assessment of heterogeneity

All included studies were identified as being moderately to highly heterogeneous, with a significant dispersion between studies, indicating there was substantial variability in the effect sizes between primary studies included. However, for the March–June comparison, a low heterogeneity and non-significant dispersion was identified, indicating that the variability in effect sizes between studies at this time point was minimal (Table 5).

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Table 5. Inferential and heterogeneity assessment statistics.

Analysis	Cohen's *d*	95% CI	*P*	Q	df (Q)	*P*	I^2
Analysis 1							
March–April	0.05	−0.18, 0.29	0.66	16.86	5	0.01	70.35
March–May	− 0.11	−0.37, 0.16	0.44	21.86	5	0.01	77.13
March–June	0.08	−0.03, 0.19	0.15	5.27	5	0.38	20.19
March–July	− 0.20	−0.54, 0.14	0.25	22.08	4	0.01	81.88
March–August	− 0.18	−0.40, 0.05	0.12	14.03	5	0.01	64.36
March–September	− 0.04	−0.38, 0.18	0.83	9.57	3	0.02	68.66
March–October	− 0.22	−0.61, 0.18	0.28	8.12	2	0.01	75.37
Analysis 2							
March–April	0.05	−0.18, 0.29	0.66	16.85	5	0.01	70.34
April–May	− 0.13	−0.36, 0.09	0.26	15.34	5	0.01	67.41
May–June	0.12	−0.12, 0.34	0.36	18.45	6	0.01	67.48
June–July	− 0.15	−0.44, 0.14	0.31	19.29	5	0.01	74.09
July–August	− 0.06	−0.21, 0.08	0.37	6.04	5	0.30	17.19
August–September	0.12	−0.02, 0.25	0.09	4.15	4	0.38	3.72
September–October	− 0.10	−0.24, 0.04	0.18	0.95	3	0.81	0.00
Analysis 3							
Baseline–end of deployment	0.15	−0.28, 0.57	0.50	20.97	4	0.01	80.93
Analysis 4							
Baseline–end of deployment	0.17	−0.03, 0.37	.10	124.62	18	0.01	85.56

CI = confidence interval.

Assessment of publication bias

Funnel plots for the March–April, March–August and March–September analyses are shown in Supplementary Figs 2–4, respectively. For the March–April analysis, under the random-effects model, the point estimate (95% CI) for the combined studies was 0.05 (-0.18, 0.25). Using trim and fill three studies were imputed, resulting in an adjusted point estimate of 0.26 (0.02, 0.36). For the March–August analysis, under the random-effects model the point estimate (95% CI) for the combined studies was 0.05 (-0.40, 0.05). Using trim and fill three studies were imputed, resulting in an adjusted point estimate (95% CI) of 0.01 (-0.23, 0.12). For the March–September analysis, under the random-effects model the point estimate (95% CI) for the combined studies was -0.04 (-0.40, 0.19). Using trim and fill one study was imputed, resulting in an adjusted point estimate (95% CI) of -0.12 (-0.47, 0.16). Cumulative meta-analyses were also conducted for the March–April, March–August and March–September analyses (Supplementary Figs 5–7). No positive drift in effect sizes was identified, thus indicating no small sample size effects.

Analysis 2

Analysis 2 investigated research question 1 using a repeated time point meta-analysis, which progressively compared monthly measurements of negative mood to the preceding month, starting with the first month of the winter-over period (March). The characteristics of included studies are listed in Table 2. As indicated in Table 5 negative mood was higher in the earlier month between March–April, May–June and August–September, whilst negative mood was higher in the later month between April–May, June–July, July–August and September–October. No significant difference progressively across months during winter was identified and all effect sizes were trivial (Fig. 2).

Assessment of heterogeneity

Heterogeneity statistics are displayed in Table 5. The progressive monthly comparisons from March to July were identified as being moderately to highly heterogeneous, with a significant dispersion among studies, indicating there was substantial variability in the effect sizes between primary studies included. However, the progressive monthly comparisons from July to October were found to have low heterogeneity and a non-significant dispersion in studies, indicating that the variability of effect sizes between studies at these time points was minimal.

Assessment of publication bias

A funnel plot for the March–April and August–September analysis is shown in Supplementary Figs 8 and 9, respectively. For the March–April analysis, under the random-effects model, the point estimate (95% CI) for the combined studies was 0.05 (-0.18, 0.25). Using trim and fill three studies were imputed, resulting in an adjusted point estimate of 0.26 (0.02, 0.36). For the August–September analysis, under the random-effects model the point estimate (95% CI) for the combined studies was 0.12 (-0.02, 0.23). Using trim and fill one study was imputed, resulting in an adjusted point estimate of 0.11 (-0.08, 0.22). Cumulative meta-analyses were also conducted for the March–April and August–September analyses shown in Supplementary Figs 10 and 11, respectively. No positive

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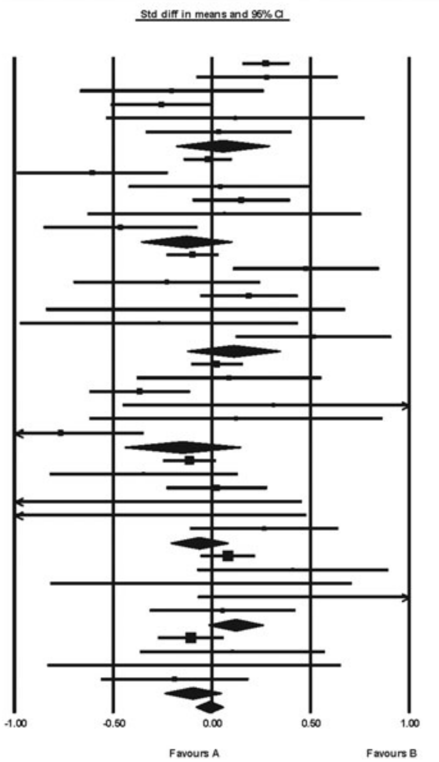
Group by Time point	Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight
March-April	Norris et al., 2010	0.27	0.06	0.00	0.15	0.39	4.49	0.00	25.21
March-April	Oliver, 1991	0.28	0.18	0.03	-0.08	0.64	1.53	0.13	16.54
March-April	Palinkas et al., 2000a	-0.20	0.24	0.06	-0.67	0.27	-0.85	0.40	13.01
March-April	Palinkas et al., 2000b	-0.26	0.13	0.02	-0.51	-0.00	-1.96	0.05	20.43
March-April	Steel, 2001	0.12	0.33	0.11	-0.54	0.78	0.36	0.72	8.68
March-April	Weiss et al., 2004	0.03	0.19	0.04	-0.34	0.41	0.18	0.85	16.13
March-April		0.05	0.12	0.01	-0.18	0.29	0.44	0.66	
April-May	Norris et al., 2010	-0.02	0.06	0.00	-0.14	0.10	-0.32	0.75	26.33
April-May	Oliver, 1991	-0.61	0.20	0.04	-0.99	-0.22	-3.10	0.00	15.82
April-May	Palinkas et al., 2000a	0.04	0.24	0.06	-0.42	0.51	0.18	0.86	13.10
April-May	Palinkas et al., 2000b	0.15	0.13	0.02	-0.10	0.40	1.18	0.24	21.32
April-May	Steel, 2001	0.06	0.35	0.13	-0.63	0.76	0.18	0.86	7.86
April-May	Weiss et al., 2004	-0.46	0.20	0.04	-0.85	-0.07	-2.33	0.02	15.57
April-May		-0.13	0.12	0.01	-0.36	0.10	-1.12	0.26	
May-June	Norris et al., 2010	-0.10	0.07	0.00	-0.23	0.03	-1.45	0.15	23.30
May-June	Oliver, 1991	0.48	0.19	0.04	0.11	0.85	2.52	0.01	15.40
May-June	Palinkas et al., 2000a	-0.23	0.24	0.06	-0.70	0.25	-0.94	0.35	12.44
May-June	Palinkas et al., 2000b	0.19	0.13	0.02	-0.06	0.44	1.49	0.14	19.62
May-June	Palinkas et al., 2000c	-0.08	0.39	0.15	-0.84	0.68	-0.21	0.83	6.90
May-June	Steel, 2001	-0.27	0.36	0.13	-0.97	0.44	-0.74	0.46	7.66
May-June	Weiss et al., 2004	0.52	0.20	0.04	0.12	0.91	2.56	0.01	14.68
May-June		0.11	0.12	0.01	-0.13	0.34	0.91	0.36	
June-July	Norris et al., 2010	0.03	0.07	0.00	-0.10	0.16	0.39	0.69	25.46
June-July	Palinkas et al., 2000a	0.09	0.24	0.06	-0.38	0.55	0.36	0.72	15.87
June-July	Palinkas et al., 2000b	-0.37	0.13	0.02	-0.62	-0.11	-2.80	0.01	22.25
June-July	Palinkas et al., 2000c	0.31	0.39	0.15	-0.45	1.08	0.80	0.42	9.44
June-July	Steel, 2001	0.12	0.38	0.14	-0.62	0.87	0.32	0.75	9.78
June-July	Weiss et al., 2004	-0.77	0.21	0.05	-1.19	-0.34	-3.56	0.00	17.20
June-July		-0.15	0.15	0.02	-0.44	0.14	-1.01	0.31	
July-August	Norris et al., 2010	-0.11	0.07	0.00	-0.25	0.02	-1.64	0.10	49.90
July-August	Palinkas et al., 2000a	-0.35	0.24	0.06	-0.82	0.13	-1.42	0.16	8.20
July-August	Palinkas et al., 2000b	0.03	0.13	0.02	-0.23	0.28	0.20	0.84	23.22
July-August	Palinkas et al., 2000c	-0.31	0.39	0.15	-1.07	0.46	-0.79	0.43	3.37
July-August	Steel, 2001	-0.34	0.42	0.18	-1.17	0.48	-0.82	0.41	2.92
July-August	Weiss et al., 2004	0.27	0.19	0.04	-0.11	0.64	1.38	0.17	12.40
July-August		-0.07	0.07	0.01	-0.21	0.08	-0.90	0.37	
August-September	Norris et al., 2010	0.08	0.07	0.01	-0.06	0.22	1.15	0.25	73.14
August-September	Palinkas et al., 2000a	0.41	0.25	0.06	-0.07	0.90	1.66	0.10	7.72
August-September	Palinkas et al., 2000c	-0.05	0.39	0.15	-0.82	0.71	-0.14	0.89	3.14
August-September	Steel, 2001	0.70	0.39	0.16	-0.07	1.48	1.78	0.08	3.07
August-September	Weiss et al., 2004	0.05	0.19	0.04	-0.32	0.43	0.29	0.77	12.93
August-September		0.12	0.07	0.00	-0.02	0.25	1.70	0.09	
September-October	Norris et al., 2010	-0.11	0.09	0.01	-0.27	0.06	-1.25	0.21	72.66
September-October	Palinkas et al., 2000a	0.11	0.24	0.06	-0.36	0.57	0.44	0.66	9.22
September-October	Palinkas et al., 2000c	-0.09	0.38	0.14	-0.83	0.65	-0.23	0.81	3.65
September-October	Weiss et al., 2004	-0.19	0.19	0.04	-0.56	0.19	-0.99	0.32	14.46
September-October		-0.10	0.07	0.01	-0.24	0.04	-1.35	0.18	
Overall		-0.01	0.03	0.00	-0.08	0.05	-0.40	0.69	



Meta Analysis

Fig. 2. Forest plot for analysis 2.

drift in effect sizes was identified, thus indicating no small sample size effects.

Analysis 3

Analysis 3 investigated research question 2 for summer deployment data. The characteristics of the included studies are listed in Table 3. There was a trivial positive effect between baseline and end of deployment scores of negative mood for summer deployment, indicating that on average negative mood scores were higher at baseline than the end of deployment (Supplementary Fig. 12).

Assessment of heterogeneity

As shown in Table 5, the included studies were found to be highly heterogeneous, indicating that there was substantial variability in the effect sizes between studies.

Assessment of publication bias

A funnel plot for this analysis is shown in Supplementary Fig. 13; under the random-effects model the point estimate (95% CI) for the combined studies was 0.14 (-0.28, 0.45). Using trim and fill three studies were imputed, resulting in an adjusted point estimate (95% CI) of 0.56 (0.11, 0.80). The cumulative meta-analysis showed no positive drift, indicating no small sample size effects (Supplementary Fig. 14).

Analysis 4

Analysis 4 investigated research question 2 for winter deployment data. The characteristics of the included studies are listed in Table 4. There was a trivial positive effect size between baseline and end of deployment scores of negative mood for winter deployment personnel, indicating that on average negative mood scores were higher at baseline than at end of deployment (Supplementary Fig. 15).

Assessment of heterogeneity

As shown in Table 5, the included studies were found to be highly heterogeneous, indicating that there was substantial variability in the effect sizes between studies.

Assessment of publication bias

A funnel plot for this analysis is shown in Supplementary Fig. 16. Under the random-effects model the point estimate (95% CI) for the combined studies was 0.17 (−0.03, 0.30). Using trim and fill three studies were imputed, resulting in an adjusted point estimate (95% CI) of 0.31 (0.10, 0.36). As shown in Supplementary Fig. 17, the cumulative meta-analysis did indicate a positive drift as studies with smaller sample sizes were added to the analysis. However, on closer investigation the majority of the computed effect sizes aligned with the study with the

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largest sample size (Norris, 2010), thus the impact of small sample sizes in this analysis is believed to be minimal.

Discussion

The current meta-analysis examined whether there was evidence of time-dependent mood fluctuations in Antarctic populations. To achieve this, four analyses were conducted to investigate two research questions of interest.

To investigate research question 1, two repeated-measures all time points analyses using random-effects models were conducted on datasets containing monthly measurements of negative mood. To show support for the third-quarter phenomenon a significant increase in negative mood during August and September was required; yet this was not identified, as trivial effect sizes were found in both analyses 1 and 2 in August and September. Therefore, the findings of the current meta-analysis do not support the proposed parameters of the third-quarter phenomenon in Antarctic personnel.

These findings suggest that previous research which had identified mood fluctuations consistent with the third-quarter phenomenon may have been confounded by the data collection or analysis methods utilised, as a number of articles can be identified as either collecting data in quarters or analysing and reporting data in quarters despite collecting data in monthly intervals. This notion is further supported by analyses 1 and 2 identifying a decrease in negative mood in June. When data are analysed in quarters this decrease in negative mood would fall in the second quarter, thus decreasing the overall negative mood average for the second quarter. Therefore, when negative mood returns to the approximate baseline identified in the majority of months during the winter deployment period, it would appear that negative mood increases. This would result in an increased overall negative mood average in the third-quarter, thus creating the appearance of a 'peak' in negative mood, paralleling the proposed parameters of the third-quarter phenomenon.

The postulation that negative mood would increase at the third-quarter point of deployment in Antarctica holds limited validity when considering the physical and social parameters which may impact mood fluctuations. The third-quarter point of winter deployment falls at the end of August. From a psychological perspective, at this point in deployment the longest day of winter (21 June) has passed resulting in twilight and daylight hours beginning to increase (AAD, 2015b), as well as increases in the average daily temperature (Australian Bureau of Meteorology, 2016). The improving weather conditions allow personnel to engage in field trips and off-station activities to a greater degree, which has been correlated with a decrease in negative mood (Wood, Hysong, Lugg, & Harm, 2000). Concurrently, the postulation that negative mood would peak at the third-quarter of deployment has limited support from the perspective of the social parameters experienced during deployment in Antarctica. August marks the beginning of the post-winter fly-in ('Winfly'), during which a small number of new personnel and supplies arrive in Antarctica via plane to prepare for the peak research season in summer. Yet if the arrival of new crew and supplies were a contributing factor to an increase in negative mood, we would predict a peak over and above what would be reported in August, in October. During October the majority of incoming Winfly flights occur, resulting in a 75% population increase in most research bases. Therefore, if the increase in the population on research bases were to negatively impact on mood, it would be more valid to assume that negative mood would increase in October, in the fourth-quarter (not third-quarter) of deployment.

Despite the current results showing no significant fluctuations in mood during the winter deployment period, analysing in monthly intervals identified several points where mood observably fluctuated. Analysis 1 (monthly by baseline) and analysis 2 (monthly progressively) showed a decrease in negative mood in June. June 21st signifies the shortest day of the year, with the event celebrated with mid-winter festivities at a majority of Antarctic research bases. As a decrease in negative mood in June coincides with such a significant milestone in the Antarctic social calendar, this suggests that the social parameters and events that occur within the research bases during the winter-over period may impact the mood of personnel.

Analyses 1 and 2 also indicated an increase in negative mood in October, which is generally the final month of the winter deployment period. As indicated, this increase in negative mood coincides with the end of Winfly and the change in deployment seasons and personnel teams. Relatively little research has been conducted on the impact of Winfly on personnel deployed during the winter-over period, yet qualitative research by Cravalho (1996) suggested that winter-over personnel were resistant to new personnel arriving and were commonly perceived by incoming personnel as disgruntled, irritable and inhospitable, indicating an increase in negative mood.

As the current analysis does not support the proposed parameters of the third-quarter phenomenon it has significant theoretical implications as this has been the dominant model used to investigate the psychological impacts of deployment in Antarctica. Analysing data in monthly intervals indicated that mood fluctuated constantly throughout deployment, yet to date there is no theoretical framework to justify why this may be occurring. Furthermore, the identification that mood may be impacted by the changing social parameters and dynamics within the base suggests that this may be an important moderator to investigate in future research. Gaining a deeper understanding of how the changing social parameters and dynamics impact personnel may assist in understanding the underlying mechanisms which impact psychological functioning during Antarctic deployments.

Furthermore, this finding has implications from both a research and an organisational perspective. First, from a research perspective, it indicates that a change in the way data are collected, analysed and reported is required. Arguably, smaller weekly intervals between assessments of psychological functioning would provide the greatest insight into adaptation and functioning during deployment. However, this may also be impractical due to the restraints and work schedules of Antarctic personnel. Therefore, it is suggested that measuring psychological functioning monthly holds the greatest utility, as it will parallel the monthly medical check-ups, which are mandatory across a number of Antarctic research bases. From an organisational perspective, the constant fluctuations in mood during the winter deployment period suggest that psychological interventions should not be targeted at any particular point of deployment. Instead, prevention strategies aimed at reducing the likelihood of mood fluctuations reaching a detrimental level may be most beneficial to overall personnel adaptation and functioning, and the productivity of the research base (Norris, 2010).

To investigate research question 2, an analysis for summer deployment data (analysis 3) and winter deployment data (analysis 4) was conducted using random-effects models on datasets containing baseline and end of deployment measurements of negative mood. Analyses 3 and 4 found a non-significant trivial positive effect size, indicating that negative mood was higher at baseline in comparison with the end of deployment in both deployment seasons. Therefore, these results suggest that deployment in Antarctica does not have a detrimental impact on psychological functioning in either the summer or winter deployment periods.

Although trivial, a positive effect size in both analyses (indicating that negative mood is higher at baseline in comparison with the end of deployment) suggests that the lead-up phase to Antarctic deployment may be more detrimental to functioning than the actual deployment period itself. The pre-deployment phase extends from when preparations for deployment to Antarctica begin until personnel physically depart for Antarctica (Norris, 2010). As there is limited formal research investigating the impacts of pre-deployment on Antarctic personnel, pre-existing research provides limited insight into why an increase in negative mood may be occurring at this time point (Norris et al., 2010). However, research on populations deployed in other EUEs, such as military personnel, or for prolonged periods, such as oil rig workers or deep sea fishers, suggests the pre-departure phase poses unique challenges to the individuals about to be deployed (Norris et al., 2010). The impending separation from family and existing social support in these populations has been correlated with feelings of guilt, frustration, anger and emotional withdrawal (Fredrickson, 2001). It is also likely to be associated with cognitive and behavioural preparations for the deployment period, in which there may be substantial renegotiation of roles between partners and within families, including administration demands and parenting obligations (Norris, 2010), all of which may result in an increase in negative mood.

As indicated, there is limited research investigating the impacts of the pre-deployment phase on Antarctic personnel (Norris et al., 2010); therefore, the current finding that the pre-deployment phase has an impact on mood suggests that future research should attempt to understand what factors impact personnel functioning in the lead up to Antarctic deployment. Understanding the mechanisms influencing the pre-departure functioning of personnel will not only assist from a theoretical perspective but will also have significant utility from a practical perspective as it will assist in the adaptation of current training and development of prevention programmes. This in turn may have substantial benefits and flow-on effects for subsequent adjustment and adaptation in later stages of Antarctic deployment (Norris, 2010).

Considerations for interpretation and recommendations for future research

The results of the current meta-analysis can only be interpreted with a number of potential limitations taken into consideration. The quality of a meta-analysis is determined by the studies selected for inclusion (Lipsey & Wilson, 2001). Therefore, a bias in the selection process can detrimentally impact the results and conclusions drawn from the meta-analysis. To minimise this potential bias, the current meta-analysis stated explicit inclusion and exclusion criteria, and calculated the inter-rater reliability of a random selection of studies that met the explicit criteria. Publication bias is another bias pertaining to the selection process, which was addressed by calculating the trim and fill method by Duval and Tweedie (2000) and conducting a cumulative meta-analysis, as described in the methods.

The 'apples and oranges' criticism of meta-analyses argues that logical and valid conclusions cannot be drawn when aggregating dissimilar studies in terms of scales of measurement, definition of variables and participants (Sharpe, 1997). This criticism concerns the current meta-analysis due to the diffuse nature of the data included, particularly the wide range of measurement scales utilised in the primary articles to investigate mood fluctuations in Antarctic personnel, impacting comparability between studies. However, Morris (2007) suggested that this concern depends on the nature of the research questions. The research questions guiding the current analysis are very broad. Further, the body of empirical knowledge associated with the research questions can be argued as niche, thus systematic exclusion on the basis of measurement scales used in the primary articles could have led to biased results or no meta-analysis being conducted. The symptoms identified as impacting an individual during Antarctic deployment include a range of negative mood states including anxiety, depression, agitation and anger. As all the scales included in the meta-analysis measure one of these outcomes, it can be argued that the current results still provide insight into mood fluctuations, despite the wide variety of scales used. The wide range of scales used suggests a lack of consensus among researchers surrounding how to best measure the psychological impacts of Antarctic deployment. Future research in this area would benefit from either the development of a specific scale or consensus about which pre-existing clinical scale holds the most utility in assessing psychological impacts of Antarctic deployment. This would improve comparability of data collected across Antarctic research bases and decrease the diffuse nature of data in an already inherently difficult research area.

The small sample sizes in the primary research articles included in the meta-analysis can also be identified as a limitation. Small sample sizes are an inherent methodological limitation of Antarctic research due to the small populations available to participate (Bhargava et al., 2000). Unfortunately, this limitation is currently impossible to overcome. Thus systematic reviews and meta-analyses hold value in this area of research, as they help accumulate and summarise existing research, providing a more complete understanding of the data than a stand-alone study can (Shea et al., 2011). Despite this, it must be acknowledged that the inclusion of studies with small sample sizes in meta-analyses can result in lower methodological quality of the meta-analytic outcomes (Greco, Zangrillo, Biondi-Zoccai, & Landoni, 2013). The current analysis used weighted effect sizes and cumulative meta-analyses to investigate and limit the bias introduced to the current analysis by small sample sizes. Further, including primary studies with small sample sizes tends to inflate the overall effect (Button et al., 2013), though as the current analyses identified trivial and small effect sizes, this has not appeared to substantially impact the current results. The need for larger sample sizes in Antarctic research suggests the need for greater collaboration between researchers in future studies. Collaboration between researchers not only increases the potential number of participants available for each study, but may also increase the consistency in data collection methods.

The current meta-analysis was limited in ability to describe the mechanisms influencing mood fluctuations in Antarctic personnel. This constraint stems from both the lack of investigation into potential moderating and mediating factors in the primary studies, and the descriptive nature of data in this research discipline. Although several moderating and mediating factors have been suggested, including team dynamics (Burke & Feitosa, 2015), leadership (Stuster, 1997), severity of weather conditions (Chen, Wu, Li, Zhang, & Xu, 2016) and culture (Palinkas et al., 2004), very few studies investigating mood fluctuations in Antarctic personnel adequately measure or investigate these factors, resulting in insufficient statistical information. Without future research investigating potential variables associated with these proposed mechanisms, research in this area will remain at the descriptive level and hold limited utility to inform the training and support of personnel. Therefore, future research should aim to progress beyond the descriptive level, which is focused on ‘if’ mood fluctuations occur, to focus on ‘why’ they occur. This progression from descriptive to explanatory research will hold greater utility in designing prevention and intervention programmes for personnel.

Generalisability of results

Although results from meta-analyses are considered more generalisable than results from a stand-alone study, the current meta-analysis is constrained by the focus on negative mood. Negative mood is only one component of the identified symptoms impacting upon an individual during Antarctic deployment with deficits in memory, concentration and fatigue also being identified. As cognitive and physical symptoms were not assessed in the current meta-analysis, the results cannot be generalised to these domains of functioning. As such, future research should aim to accumulate and summarise the respective research in these domains. Furthermore, although research investigating the impact of Antarctic deployment on personnel reflects a primarily pathogenic focus, researchers are increasingly investigating the salutogenic impacts in this domain. Thus, future research may also benefit from summarising salutogenic research in this area, as it has the potential to provide insight into the strategies personnel use to cope in Antarctica (Zimmer et al., 2013), which can be fostered through proactive prevention and training programmes.

Conclusion

The current meta-analysis indicated that mood fluctuations in Antarctic personnel are not consistent with the proposed parameters of the third-quarter phenomenon when the confound of analysing data in quarters is removed. It was identified that negative mood is higher at baseline in comparison with post-deployment in both summer and winter deployment personnel. The present findings have significant theoretical implications as they do not support the dominant theory utilised when investigating the psychological impacts of deployment in Antarctica. From a practical perspective, the results of the current meta-analysis can be utilised to adjust deployment training and prevention programmes.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S003224741700050X

References

AAD. (2015a). *Geography*. Kingston, TAS: Australian Antarctic Division. Retrieved from http://www.antarctica.gov.au/about-antarctica/environment/geography.

AAD. (2015b). *Weather*. Kingston, TAS: Australian Antarctic Division. Retrieved from http://www.antarctica.gov.au/about-antarctica/environment/weather/sunlight-hours.

Australian Bureau of Meteorology. (2016). *Antarctic and southern ocean weather*. Melbourne, VIC: Australian Bureau of Meteorology. Retrieved from http://www.bom.gov.au/ant/?ref=hdr.

Barbarito, M., Baldanza, S., & Peri, A. (2001). Evolution of the coping strategies in an isolated group in an Antarctic base. *Polar Record*, *37*, 111–120.

Bechel, R. V., & Berning, A. (1991). The third-quarter phenomenon: do people experience discomfort after stress has passed? In: Harrison, A., Clearwater, Y. A., & McKay, C. P. (Eds.). *From Antarctica to Outer Space: life in isolation and confinement* (pp. 261–266). New York, NY: Springer-Verlag.

Bhargava, R., Mukerji, S., & Sachdeva, U. (2000). Psychological impact of the Antarctic winter on Indian expeditioners. *Environment and Behavior*, *32*, 111–127.

Borenstein, M., Hedges, L. V., Higgins, J., & Rothstein, H. R. (2009). Effect sizes based on means. In: Borenstein, M. (Ed.). *Introduction to meta-analysis* (pp. 21–32). Hoboken, NJ: Wiley-Blackwell.

Borenstein, M., Hedges, L. V., Higgins, J., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods*, *1*, 97–111.

Burke, C. S., & Feitosa, J. (2015). *Team culture issues for long-duration exploration missions* (NASA/TM-2015-218587). Houston, TX: Johnson Space Center. Retrieved from: https://ston.jsc.nasa.gov/collections/trs/_techrep/TM-2015-218587.pdf.

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*, 365–376

Chen, N., Wu, Q., Li, H., Zhang, T., & Xu, C. (2016). Different adaptations of Chinese winter-over expeditioners during prolonged Antarctic and sub-Antarctic residence. *International Journal of Biometeorology*, *60*, 737–747.

Connors, M. M., Harrison, A. A., & Akins, F. R. (1985). *Living aloft: human requirements for extended spaceflight*. Washington, DC: National Aeronautics and Space Administration.

Cravalho, M. (1996). Toast on ice: the ethnopsychology of the winter-over experience in Antarctica. *American Anthropological Association*, *24*, 628–656.

Del Re, A. C., Maisel, N., Blodgett, J., Wilbourne, P., & Finney, J. (2013). Placebo group improvement in trials of pharmacotherapies for alcohol use disorders: A multivariate meta-analysis examining change over time. *Journal of Clinical Psychopharmacology*, *33*, 649.

Duval, S., & Tweedie, R. (2000). A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *Journal of the American Statistical Association*, *95*, 89–98.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: the broaden-and-build theory of positive emotions. *American Psychologist*, *56*, 218.

Greco, T., Zangrillo, A., Biondi-Zoccai, G., & Landoni, G. (2013). Meta-analysis: pitfalls and hints. *Heart Lung Vessel*, *5*, 219–225.

Harris, A., Marquis, P., Eriksen, H. R., Grant, I., Corbett, R., Lie, S. A., & Ursin, H. (2010). Diurnal rhythm in British Antarctic personnel. *Rural Remote Health*, *10*, 1351.

Ikegawa, M., Kimura, M., Makita, K., & Itokawa, Y. (1998). Psychological studies of a Japanese winter-over group at Asuka Station, Antarctica. *Aviation Space and Environmental Medicine*, *69*, 452–460.

Johnson, J. C., Boster, J. S., & Palinkas, L. A. (2003). Social roles and the evolution of networks in extreme and isolated environments. *Journal of Mathematical Sociology*, *27*, 89–121.

Kanas, N. A., & Fedderson, W. E. (1971). *Behavioral, psychiatric, and sociological problems of long-duration space missions* (NASA-TM-X-58067). Retrieved from National Aeronautics and Space Administration: https://ntrs.nasa.gov/search.jsp?R=19720008366

Khandelwal, S., Bhatia, A., & Mishra, A. K. (2015). Psychological health in the summer team of an Indian expedition to Antarctica. *Journal of Mental Health and Human Behaviour*, *20*, 65.

Lilburne, L. (2005). *Shrinks on ice: a review of psychosocial research in Antarctica* (Graduate Certificate in Antarctic Studies). Christchurch: University of Canterbury. Retrieved from http://www.anta.canterbury.ac.nz/documents/GCAS_7/Lilburne_L_Lit.Review.pdf.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49). Thousand Oaks, CA: Sage Publications.

McCormick, I. A., Taylor, A. J. W., Rivolier, J., & Cazes, G. (1985). A psychometric study of stress and coping during the International Biomedical Expedition to the Antarctic (IBEA). *Journal of Human Stress*, *11*, 150–156.

McDaniel, M. A. (2009). *Cumulative meta-analysis as a publication bias method*. Paper presented at the annual meeting of the Society for Industrial and Organizational Psychology, New Orleans, LA.

Mocellin, J. S., Suedfeld, P., Bernadelz, J. P., & Barbarito, M. E. (2000). Levels of Anxiety in Polar Environments. Journal of Human Performance in Extreme Environments, *5*(1), 29–34. doi: 10.7771/2327-2937.1004

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of Internal Medicine*, *151*, 264–269.

Monette, D. R., Sullivan, T. J., & DeJong, C. R. (2013). *Applied social research: a tool for the human services*. Boston, MA: Cengage Learning.

Morris, S. B. (2007). Methods of meta-analysis: correcting error and bias in research findings. In: Hunter, J. E., & Schmidt, F. L. (Eds.). *Organizational research methods* (pp. 483–512).

Nicolas, M., Suedfeld, P., Weiss, K., & Gaudino, M. (2016). Affective, social, and cognitive outcomes during a 1-year wintering in Concordia. *Environment and Behavior*, *48*, 1073–1091.

Norris, K. A. (2010). *Breaking the ice: developing a model of expeditioner and partner adaptation to Antarctic employment* (unpublished doctoral dissertation). Hobart, TAS: University of Tasmania.

Norris, K. A., Paton, D., & Ayton, J. (2010). Future directions in Antarctic psychology research. *Antarctic Science*, *22*, 335–342.

Oliver, D. C. (1991). Psychological effects of isolation and confinement of a winter-over group at McMurdo Station, Antarctica. In: Harrison, A. A., Clearwater, Y. A., & McKay, C. P. (Eds.). *From Antarctica to Outer Space: life in isolation and confinement* (pp. 217–227). New York, NY: Springer-Verlag.

Palinkas, L.A. (1991). Effects of physical and social environments on the health and well-being of Antarctic winter-over personnel. *Environment and Behavior*, *23*, 782–799.

Palinkas, L. A., & Browner, D. (1995). Effects of prolonged isolation in extreme environments on stress, coping, and depression. *Journal of Applied Social Psychology*, *25*, 557–576.

Palinkas, L. A., Gunderson, E. K., Johnson, J. C., & Holland, A. W. (1999). *Behavior and performance on long-duration spaceflights: evidence from analogue environments*. Retrieved from https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20000068515.pdf.

Palinkas, L. A., & Houseal, M. (2000). Stages of change in mood and behavior during a winter in Antarctica. *Environment and Behavior*, *32*, 128–141.

Palinkas, L. A., Houseal, M., & Rosenthal, N. E. (1996). Subsyndromal seasonal affective disorder in Antarctica. *Journal of Nervous and Mental Disease*, *184*, 530–534.

Palinkas, L. A., Johnson, J. C., Boster, J. S., Rakusa-Suszczewski, S., Klopov, V. P., Fu, X. Q., & Sachdeva, U. (2004). Cross-cultural differences in psychosocial adaptation to isolated and confined environments. *Aviation, Space, and Environmental Medicine*, *75*, 973–980.

Palinkas, L. A., & Suedfeld, P. (2008). Psychological effects of polar expeditions. *Lancet*, *371*, 153–163.

Peri, A., Scarlata, C., & Barbarito, M. (2000). Preliminary studies on the psychological adjustment in the Italian Antarctic summer campaigns. *Environment and Behavior*, *32*, 72–83.

Peters, J. L., & Mengersen, K. L. (2008). Meta-analysis of repeated measures study designs. *Journal of Evaluation in Clinical Practice*, *14*, 941–950.

Rogelberg, S. G. (2008). *Handbook of research methods in industrial and organizational psychology* (Vol. 5). Oxford: Wiley-Blackwell.

Schmidt, F. L., & Hunter, J. E. (2014). Methods of meta-analysis: Correcting error and bias in research findings. London, England: Sage publications.

Sharpe, D. (1997). Of apples and oranges, file drawers and garbage: why validity issues in meta-analysis will not go away. *Clinical Psychology Review*, *17*, 881–901.

Shea, C., Slack, K. J., Keeton, K. E., Palinkas, L. A., & Leveton, L. B. (2011). *Antarctica meta-analysis: psychosocial factors related to long-duration isolation and confinement*. Washington, DC: National Aeronautics and Space Administration. Retrieved from http://ston.jsc.nasa.gov/collections/TRS/.

Steel, G. D. (2001). Polar moods: third-quarter phenomena in the Antarctic. *Environment and Behaviour*, *33*, 126–133.

Stuster, J. (1997). *Human adjustment to isolation and confinement*. Paper presented at the 27th International Conference on Environmental Systems, Lake Tahoe, NV. Retrieved from http://papers.sae.org/972399/.

Stuster, J., Bachelard, C., & Suedfeld, P. (2000). The relative importance of behavioral issues during long-duration ICE missions. *Aviation, Space, and Environmental Medicine*, *71*, 17–25.

Suedfeld, P., & Steel, G. D. (2000). The environmental psychology of capsule habitats. *Annual Review of Psychology*, *51*, 227–253.

Ursin, H., Bergan, T., Collet, J., Endresen, I. M., Lugg, D. J., Maki, P., . . . Pettersen, R. (1991). Psychobiological studies of individuals in small, isolated groups in the Antarctic and in space analogues. *Environment and Behavior*, *23*, 766–781.

Weiss, K., & Gaud, R. (2004). Formation and transformation of relational networks during an Antarctic winter-over. *Journal of Applied Social Psychology*, *34*, 1563–1586.

Weiss, K., Suedfeld, P., Steel, G. D., & Tanaka, M. (2000). Psychological adjustment during three Japanese Antarctic research expeditions. *Environment and Behavior*, *32*, 142–156.

Wilson, D. (2011). *The third-quarter phenomenon in Antarctic personnel: literature review* (masters dissertation). Christchurch: University of Canterbury. Retrieved from http://www.anta.canterbury.ac.nz/documents/PCAS_13/PCAS_13_Wilson_D_Literature_The_Third_Quarter_Phenomenon.pdf.

Wood, J., Hysong, S. J., Lugg, D. J., & Harm, D. L. (2000). Is it really so bad? A comparison of positive and negative experiences in Antarctic winter stations. *Environment and Behavior*, *32*, 84–110.

Xu, C., Zhu, G., Xue, Q., Zhang, S., Du, G., Xi, Y., & Palinkas, L. A. (2003). Effect of the Antarctic environment on hormone levels and mood of Chinese expeditioners. *International Journal of Circumpolar Health*, *63*, 255–267.

Young, I., Waddell, L., Harding, S., Greig, J., Mascarenhas, M., Sivaramalingam, B., . . . Papadopoulos, A. (2015). A systematic review and meta-analysis of the effectiveness of food safety education interventions for consumers in developed countries. *BMC Public Health*, *15*, 1–14.

Zimmer, M., Cabral, J. C. C. R., Borges, F. C., Côco, K. G., & Hameister, B. R. (2013). Psychological changes arising from an Antarctic stay: systematic overview. *Estudos de Psicologia (Campinas)*, *30*, 415–423.