Human change and adaptation in Antarctica: Psychological research on Antarctic wintering-over at Syowa station

Tomoko Kuwabara a,b, Nobuo Naruiwa c, Tetsuya Kawabe d, Nanako Kato e, Asako Sasaki f, Atsushi Ikeda g, Shinji Otani h, Satoshi Imura i, Kentaro Watanabe j and Giichi Ohno k

Introduction

Antarctica is one of the most extreme environments on earth for humans, and wintering-over in Antarctica is especially difficult. Though significant developments have been made in wintering-over operations, it is still hard to stay an entire year in an Antarctic station, not only because of the cold, changes in daylight, and exposure to UV-rays and the highland, but also isolation and the impossibility of escaping from one’s small social group[1].

These conditions make an Antarctic station a unique society that can reveal much about human nature. It is a significant challenge to study the human mind in Antarctica. This study aims to describe psychological diagnoses at such a distance.

The living conditions in the Antarctic station are significantly different from what is normal for Japanese people, and wintering teams are required to endure these conditions for long periods of time. Although these conditions may bring about a uniquely positive mental state, many team members do experience psychological distress. Understanding team members’ states of mind and monitoring their living conditions to ensure that no psychological crises occur is a key concern when developing a potential emotional support system.

Background

History

Various studies have been conducted on the effects of staying in Antarctica on human psychology, as shown by an excellent review by 2. Many studies measure psychological changes before and after arriving in Antarctica, but most are only sporadic measurements. There are some systematic studies that conducted the measurements repeatedly, such as 3–6, but they...
analysed only a year’s worth of data. This research is of great significance since we conducted a survey of five wintering-over teams and measured each of them six times.

Psychological testing of Japanese wintering teams was suspended for about ten years because the methods used had proved to be too invasive. However, in 2003, the National Institute of Polar Research (NIPR) received a proposal for a research project on an international comparison of wintering team members’ mental states. That was an opportunity to recommence the long-suspended psychological research on Japanese wintering teams.

In re-starting psychological surveys, we were aware of the importance of adopting non-invasive techniques that would consider the mental stability of the members of the wintering parties, rather than using conventional methods of externally observing and testing. We explored the ways of conducting psychological testing that would contribute towards team members’ mental wellbeing, introducing techniques that would address their inner emotions and help them understand their dynamic psychological states.

**An isolated Antarctic wintering-over station**

The Japanese Antarctic Research Expedition (JARE) has continuously wintered over at Syowa Station in eastern Antarctica since 1956. The station site is S 69°, E 39°, on a small island 4 km from the continent. The temperature is 0°C in summer, minus 40°C in winter. There is uninterrupted sunlight in December and January and polar nights without any sunrise in June and July.

The number of wintering-over team members has increased and their composition has changed with the scale of the station; recently, the team comprised 30 members with an average age of 39. Team members range from people in their 20 s to 60 s. In 1998, two women joined the wintering-over team for the first time, and after that, women have participated consistently.

Every wintering-over team leaves Japan at the end of November. About one year before departure, participants join the team from various departments of different institutes. They undergo medical screening, including psychological tests. A week-long winter training camp is held in March, where the members meet each other for the first time. Another week-long summer training camp is held in June. The team gathers in the expedition office in July and works together daily, preparing for departure.

In December, Japanese expeditioners board an icebreaker from Australia. The ship is the only regular transport to the Japanese Antarctic station, and it takes a month to reach the Syowa station. Upon arrival, the team members have a short summer season to prepare for wintering over. The ship leaves the station in the following February with the previous wintering party. Because of thick ice, bad weather, and winter darkness, there is no transportation available until the next ship in the following December. The team is completely isolated for ten months without rescue or evacuation services. The next summer, they return to Japan by the icebreaker in March after 16 months.

**Methods**

**Organisational Structure**

Figure 1 shows the organisational structure of the research project. A medical doctor, who is also a part of the Antarctic medical research group of the NIPR, travels to Syowa Station to carry out psychological testing on the wintering party. After his return to Japan, the analysis results are sent to the NIPR. The Antarctic Psychological Research Team of Kyoto University, with which we are affiliated, analyzes the data brought back by the medical doctor. Further, personal data are given as feedback to each wintering party member when they return to Japan.

The following initiatives were used to make members feel at ease while undergoing psychological testing and to give them a sense that they were helping themselves by participating.

1. Participation was voluntary. Members were not forced to undergo any test and could withdraw whenever they wished to.
2. They were informed that any psychological data obtained would be kept confidential, under lock and key, during the winter.
3. The results would be given as feedback to the members on returning to Japan.

This research was approved by the research ethics committee of Kyoto Koka Women’s University.

**Test battery and test period**

The Antarctic Psychological Research Team of Kyoto University conducted the survey continuously for ten years (from 2004 to 2014) while updating the test battery or test periods. The survey started with the Baum
In addition to the Baum test, the following scales were administered: 1) the Positive and Negative Affect Schedule (PANAS), 2) the Coping Orientation to Problems Experienced Inventory, (COPE) 3) Subjective Health Complaints Inventory (SHC) (Ursin et al., 1988), and 4) the Two-Sided Personality Scale (TSPS). The PANAS assessed participants’ mood at the time of response to the questionnaire and was administered to half of the wintering party, while the Profile of Mood States (POMS) was given to the other half. The COPE, a self-report questionnaire developed to assess a broad range of coping responses [7], was used to identify the strategies used to relieve stress, and the SHC evaluated participants’ physical ailments.

The TSPS was developed to evaluate personality [8] by independently evaluating 30 conflicting adjectival pairs (such as “gentle” versus “firm” as shown in Figure 3). In the example in the figure, “gentle” is highly applicable, while “firm” is “somewhat applicable”. When participants score themselves highly on two contradictory adjectives, their personalities are said to have a high degree of two-sidedness. Conversely, when disproportionate emphasis is placed on one adjective in a pair, a low degree of two-sidedness is registered; that person is said to have a one-sided personality.

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1The survey method of questionnaires is effective in measuring the conscious attitudes of participants, but it is apt to be influenced by biases like social desirability. Therefore, we decided to use a projective technique together with questionnaires. The projective technique is less susceptible to bias and conscious distortion of answers. The use of drawings in this technique, especially has a useful characteristic of visual communication; hence, it is suitable for identifying repressed feelings which are difficult to describe.
The test period and subjects are as shown in Figure 4. The research was conducted five to seven times through the winter, with varying results each time. Testing was conducted before departure from Japan (#1), at the beginning of the wintering period (#2), during the polar night (#3), at polar daybreak (#4), during the midnight sun (#5), and on the ship during the homeward journey (#6).

Results and short summaries

The Baum test

What kind of trees did they draw? The data were gathered from 172 Japanese members over five years (161 males, 11 females, Mage = 37.09 years, SD = 7.43 years). Many, across almost all test periods, drew apple trees. An apple tree is the most common type of drawing in studies using the Baum test in Japan. However, in some teams, the number of team members who drew apple trees lessened in the July test period. The result was that various trees were drawn during the polar daybreak compared to other test periods, suggesting that team members’ minds became more agile when the monotonous polar night was over. Despite living near the coldest continent, quite a few team members drew a palm tree, probably suggesting their desire to escape from life in Antarctica. Some drew trees reminiscent of Japan: such as a cherry tree, a pine tree, a tree from

Figure 3. TSPS.

Figure 4. Test Periods.
a team member’s garden in Japan. These drawings suggest that team members maintained an image of home, even while in Antarctica.

The Baum test is a projective technique based on the free drawing of a fruit tree. Our original purpose was to measure the degree of Antarctic team members’ adaptation to their environment. However, we had to change our purpose upon realising the diverse expressions in their drawings. We decided to focus on the individuality of each drawing, believing that qualitatively comprehending messages from them would be a clue to understanding the hearts and minds of the wintering team members. In theory, while taking the Baum test, Takahashi & Takahashi [9], report that “many people project themselves onto trees drawn by them, and they project their living space onto their drawing paper.” Therefore, we surmise that there are similarities between the wintering team members drawing a tree freely on a blank paper and living their new lives near a strange, glacier-covered continent.

When we focused on changes in the Baum test results over time, we found two types of constancy. In one, the participants drew the same tree every time; in the other, they drew a different kind of tree every time. There was a wide variety of individuals whose drawing patterns fell in between those extremes. These results suggest two types of coping among individuals: one stabilises life by maintaining a previous lifestyle, and the other flexibly adjusts to a new way of life.

Physical risks

A study of medical consultations that analysed 6,800 cases from Syowa station over 60 years (from 1956 to 2016, notwithstanding the gap of ten years) showed that the most frequent medical issues in the Antarctic station involved surgical and orthopaedics, followed by internal medicine, dental problems, and other diseases. Psychiatric problems made up only 2% of all consultations [10].

Figure 5 shows the frequency of colds at each test period by SHC scale. Data with missing values were excluded from the analysis. The data were gathered from 69 members over five years. About one-third of participants caught a cold within a month before departing Japan ($\chi^2(5) = 50.746$, $p < .01$ Cramer’s V = 0.350), but team members in Antarctica hardly ever caught a cold, presumably because the fewer impurities in the air resulted in a lower prevalence of colds at Syowa Station. In addition, a few people experienced heartburn in Antarctica, perhaps from having meals prepared exclusively by licenced cooks. Minor illnesses had a lower prevalence in Antarctica than in Japan.

Figure 6 shows that the number of team members who experienced sleep disturbances was few at the beginning of the wintering period and increased on the ship during the homeward journey. ($\chi^2(5) = 25.556$, $p < .01$ Cramer’s V = 0.248). We expected the number of team members who experienced sleep disturbances to

![Figure 5](image_url)
increase during the polar night when the sun did not rise and their inability to distinguish between day and night disrupted their circadian rhythms. The proportion of people describing conditions as “severe” showed an increase during the polar night, but the differences were not statistically significant. Rather than the polar night, the number of people who experienced sleep disturbances increased on the ship during the homeward journey, which applies to the season of transition to new circumstances and ship shaking, so it was thought that those factors influenced their sleep disturbances. These results and the post-mission interview suggest the following. There are risk factors for sleep other than a change in daylight hours. The midnight-sun period is when the next wintering team members and summer members arrive and when the end of the mission approaches. When work or research does not go as planned, irritability, or hyperactivity and, ultimately, sleep disturbances may result. They may also result from stress and from strained human relationships after having been stationed at one site for a long time. The “third quarter phenomenon” [11], an increase in the cluster of symptoms consisting of sleep disturbance, impaired cognition, negative affect, and interpersonal tension and conflict could also play a role. As experienced by people on polar expeditions in the Antarctic, this occurs after the midpoint of an expedition, with some reduction in symptoms towards the end [2].

Is there any connection between physical ailments and a team member’s awareness of their own stress? This question led to our analysis of the relationships between team members’ free descriptions of their stress and physical ailments, using discriminant analysis [12]. The results showed a tendency among team members with upper gastrointestinal digestive problems (e.g. heartburn, stomach discomfort, gastritis, and stomach ache) to report awareness of some type of stress. However, members with lower gastrointestinal digestive problems (e.g. flatulence, diarrhoea, and constipation) or pulmonary symptoms did not make any reference to stress. These results suggest that asking participants to report subjectively on their ailments using a questionnaire is insufficient; certain conditions may dull one’s stress awareness.

**Changes in mood**

Using the PANAS [13], we measured changes in mood during winter in Antarctica. The data were gathered from 63 members over three years. This scale consisted of two factors and had enough reliability ($\alpha = .89, .86$). As shown in Figure 7, the positive affect significantly decreased before departure and on the return ship but remained constant during the wintering-over period. From this result and analysis of interview contents of the members of the wintering party after returning to Japan, it is presumed that they had fewer positive
feelings, and perhaps anticipatory dread, while preparing before departure. However, upon arrival in Antarctica, they were impressed by the setting, enjoyed a warm and comfortable base and delicious meals prepared by professional cooks, and, above all, could concentrate on their work and research. We speculate that those factors helped lessen people’s loneliness when far from home and enhanced their positive affect. [2], noted that, despite experiencing various symptoms, syndromes, and disorders, people in polar regions also experience positive affect.

Figure 8 shows that negative affect peaked slightly at the beginning of the midnight sun; however, it was insignificant. Our previous research [14] has shown that the negative affect comprises anger and hostility.

Figure 7. Positive Affect Score.

Figure 8. Negative Affect Score.
Personality

Analysis of the personality of 111 wintering personnel over three years in Antarctica, using the TSPS [8], showed two types of adaptation to the region. The reliability of the scale by measuring check items was high enough (r = .717). One was the maintenance of single-minded devotion, and the other was flexible adaptation according to situations. Chi-square analyses revealed these two types were more common than others (p < .01). Currently, however, we cannot determine that there are any ideal adaptive personality traits for Antarctica.

15 noted that earlier studies showed a general concept of effective individual performance that included three essential components: task motivation, emotional stability, and social compatibility. These traits are necessary for withstanding severe environments for a prolonged period. However, this could be conceptualised differently in our situation. Someone who is seemingly not adaptable may simply gravitate towards assuming other roles in isolated and confined environments. The problem in this regard does not lie with the individual but emerges from group dynamics. If one person does not cause problems at a particular time, then another person inevitably does. This way of thinking has the advantage of saving time spent looking for the troublemaker and using it for locating problem-solvers. As mentioned previously, mood changes occur often in Antarctica, and wintering team members show different aspects of their personalities frequently. In an isolated and confined environment, these factors combine to create either good or bad emotional experiences.

Stress Coping Strategies

Using the COPE scale [7], we compared the stress coping strategies used by Japanese Antarctic wintering team members (147 people over four years) to those used by Japanese people living in Japan (221 people; 86 males, 133 females, 2 other, Mage = 41.7 years, SD = 11.5 years). This scale consisted of 15 subscales. The reliability was high enough on most subscales (α > .60), but slightly lower on some (“Mental disengagement (α = .52)”; “Denial (α = .56)”; “Restraint (α = .56)”; “Suppression of competing activities (α = .595)). However, we adopted the same items as the original version. Wintering team members were found to use “positive reinterpretation”, “active coping”, “humour”, “acceptance”, “planning”, and “seeking of instrumental social support” more often, compared to people in Japan. Moreover, people in Japan used “focus on and venting of emotions”, “denial”, and “turning to religion” more often than Antarctic team members. We speculate that wintering team members accepted their isolated environment and acted positively to overcome difficulties, and neither acted out emotionally nor denied problems. These tendencies were noticeable in the early stages of wintering.

According to the analysis of data of 107 wintering team members over five years, four types of stress coping indicated change during their wintering mission. “Use of instrumental social support”, “Acceptance”, “Planning” were high at the beginning of the wintering period but decreased as time passed. “Denial” was low throughout the wintering period but especially low at the beginning of the wintering period. From this result, it is considered that members feel nervous and obligated to achieve on wintering mission challenges at the period positively. This development had both advantages and disadvantages; for example, the decrease in “planning” meant that, although operations had become smoother, the risk of accidents may have increased. “Planning” is an important aspect of life in Antarctica, where outdoor activities necessitate approval of plans by the leader. However, low temperatures, and humidity often cause unexpected equipment breakdowns in Antarctica, and in the worst case, the planned mission could not be achieved because of broken equipment beyond repair. In such an instance, the capacity to change the initial plan was presumably related to the psychological states of the wintering team members.

Discussion

Originality of this study

There are four originalities in this study. 1) Surveys were conducted six times a year for five wintering-over teams each. 2) A questionnaire method was used in the test battery with a projective technique. 3) While the other countries’ bases on the Antarctic Peninsula are located in a place that can be reached from each other, Syowa Station has no adjacent bases and is placed in a long-term closed environment in winter. Those conditions made it possible for us to study human psychology in a “long-term closed environment” which differs from the studies of other country’s base. 4) The significance of the researcher’s absence in the field. By this method, we could ensure that one’s answer is not known to the people inside the base and hence prevent it from being biased by the relationships in the field. This could also be a noteworthy point as a non-invasive research method.
**Relationship with previous research**

About sleep disruption, the results of our survey are considered to be generally consistent with previous research that determined that the difficulty of falling or staying asleep, or both, are the characteristics of people on polar expedition, especially in midwinter [2], [16], used the NEO Five-Factor Inventory (NEO-FFI) and found that polar workers scored higher than a normative group on all factors except Neuroticism. Furthermore, we found that the wintering team members tend to have more stress coping strategies than an ordinary citizen in Japan.

**Experiences in Antarctica and a subjective image**

The Baum test gives an idea of each participant’s psyche, and the two-picture method provides a platform upon which subjects can better express their complex inner feelings. An important aspect of the Baum test for us was not that it detected an overall pattern but rather that, through the tree images drawn, it directly conveyed how each member got through their stay at the Antarctic station. Keeping in mind that not a single tree grows wild in Antarctica, studying how subjects drew trees in such an extreme environment provided us with insights into participants’ inner worlds.

[17], a clinical psychologist, pointed out the importance of subjective images in understanding a person. He stated that only when a person expresses their subjective image we can understand their inner space, including the unconscious. Each drawing reflected members’ own internal, subjectively perceived images. Many wintering team members drew a tree that seemed to project their inner space, moulded by their subjective experiences. For example, one participant drew an alpine plant near a forest line. The tree spread its branches powerfully against strong wind and snow. We interpreted that he invigorated himself in the face of adversity. Another member drew a bonsai tree that displayed its beautiful branches in a spatially limited flowerpot. We interpreted this drawing as his situation, trying to do his best in environmental limitations. Another member drew a drooping cherry tree that maintained its grace in the face of a strong wind. We interpreted drooping branches as his flexibility in the face of headwind in the Antarctic station. As outside viewers, we could grasp how each person felt in the depths of their hearts when they expressed themselves through such images. We could identify team members’ pain tightly squeezed into a drawing and imagine how they conquered difficulties by themselves. In addition, we read human toughness and flexibility into images such as a small tree standing against wind and snow and the drooping cherry tree avoiding collisions.

Participants drew their work carefully. Many psychotherapists have stated that, when one surrenders oneself to the imagination, it functions automatically, and we may achieve goals beyond our expectations. Wintering team members sustained their mental health by visiting a mild temperate climate island or their hometown in their imaginations.

**“Relations” in Antarctica-Internal relationships in one’s mind**

In the past, it was difficult even to confirm the safety of members of Antarctic research expeditions; however, lately, the region has become far more connected to the outside world than ever before. The communication infrastructure has improved in the past 20 years, and members use the Internet and email whenever required. They can contact their families and friends regularly and receive real-time news outside of Antarctica. Wintering team members’ responses to emails are more prompt than those of our acquaintances in Japan. Despite developments in communication technology, some aspects of life in Antarctica remained unchanged. The physical distance between Antarctica and Japan means that if a wintering team member’s parent dies or their child is hospitalised, they can only receive news about these events but cannot return home. Thus, Antarctica remains a far distant continent.

To live for a long period in a stable, closed environment such as Antarctica, far from one’s homeland, it is important to have an internal relationship with “home”. Of course, communicating with people outside of Antarctica via email or video calls is a significant support for team members. However, such communication becomes a source of emotional support only when team members feel that sense of internal relationship. Some wintering-over team members drew Japanese trees, such as cherry and pine, as well as the trees growing in their gardens back home. Despite living in Antarctica, they maintained a relationship with home through images. When faced with the harsh reality of their environment, team members drew support from the sense of an “internal relationship” with their homeland.

**The sharing of images**

When taking the Baum test, team members were required to describe their drawings. In some cases, their written comments indicated awareness of the
researchers in Japan, probably because team members had met directly with the authors when the first survey was conducted in Japan. Such comments displayed a sense of relationship with members of our research team. For the researchers, the descriptions of tree drawings sometimes seemed like a letter from Antarctica to Japan. Team members would have been aware of the researchers’ presence, who would see their drawings and writings in Japan in the future. Even though we, the researchers, were far away in Japan, we existed in team members’ minds as recipients of their images and words. In order to adapt to collective life in Antarctica, a microcosm of society, one must suppress what is unacceptable to the group, to a certain degree. That also applies to life in Japan, and despite the severity of conditions in Antarctica, illustrations drawn there were more vibrant than those drawn in Japan. Wintering in Antarctica involves the austerity of leaving home and being isolated in a closed environment but at the same time team members leave the busy life and complicated social relationships of Japan behind. The adaptive directionality shown by the wintering team members suggests that Japanese society is more difficult to live in than the isolation of Antarctica.

In addition to this research, we provided feedback on test results and interview about experiences in Antarctica and Japan because we are concerned about not only the risk management during wintering over but also the team members’ readjustment after their return to Japan. We are planning future researches on these themes based on quantitative and qualitative data.

In societies with many restrictions, whether in Japan or Antarctica, the role of those involved in practising psychology is to share deeply internal, even repressed matters that are unacceptable to the society or the individuals. Our work would benefit not only team members living in Antarctica or returning home, but also researchers in isolated environments, in general. The conditions at Syowa Station are controlled for people to live together for a long time in the same place, which provides an ideal environment for psychological research. Observing the group dynamics of a single small group of Japanese people clarifies how human beings adapt mentally to long-term isolation and enables international comparative studies of Japanese culture. It can also be applied to predict the crew’s psychological state in future space travel.

Conclusions

From different psychological surveys over ten years, we reveal a typical image of wintering-over team members of Syowa Station: they, keeping the images of home or family in mind, accept and adapt to the difficulties of Antarctica, and work without asking questions, despite the unideal conditions.

Further research will clarify the effect of external conditions by following changes over time, the group dynamics that allow for personal diversities, and the characteristics of the Japanese people in international comparisons.

An Antarctic wintering-over station is an ideal isolated environment for psychological surveys, which can help in understanding group management in everyday societies, and also in conditions of future space travel.

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ORCID

Atsushi Ikeda http://orcid.org/0000-0003-0934-5470
Shinji Otani http://orcid.org/0000-0002-3024-3578
Satoshi Imura http://orcid.org/0000-0002-6803-6996
Kentaro Watanabe http://orcid.org/0000-0002-5177-0086
Giichiro Ohno http://orcid.org/0000-0002-5342-2667

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