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ORIGINAL PAPER

Short- and long-term memory and age in a traditional tribe (Dani of Papua) and a modern population (Poland)

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Abstract

The different environmental conditions in which people live might challenge memory in different ways. Moreover, the frequency of usage can be a source of improvement of both short- and long-term memory. The aim of our study was to investigate the effects of environmental differences on short- and long-term memory in a traditional versus a contemporary population (Dani of Papua, $n = 62$; Polish, $n = 134$). We found that both short- and long-term memory varied in the two populations, living in totally distinct surroundings. However, there were no age differences between Polish and Dani participants in either short- or long-term memory tasks, indicating that culture was not a significant moderator of the memory differences between populations. The differences in short- and long-term memory between the two populations are consistent with the argument that short-term memory plays a more significant role in contemporary societies because of technical developments, the electronic revolution, and reading ability. The lack of an age difference appears to support the assumption that it is age, not culture, that plays a crucial role in the memory performance.

Keywords Aging · Memory · Long-term memory · Short-term memory · Papua

Studies on human memory have shown the crucial role of two basic types of memory: short-term memory (STM) and long-term memory (LTM) (e.g., Atkinson and Shiffrin 1968; Baddeley et al. 1975; Cammarota et al. 2005; Norris 2017; Waugh and Norman 1965). Both types appear to be essential to human cognitive processes and everyday activities. The distinction between STM and LTM has been extensively described in classical works by, for example, Atkinson and Shiffrin (1968) and Waugh and Norman (1965). In essence, LTM is described as a system or systems assumed to underpin the capacity to store information over long periods of time (Rumelhart et al. 1972), whereas STM holds small amounts of information over a period of a few seconds and then reproduces it in an untransformed fashion (Baddeley et al. 1975; Swanson et al. 2009).

Living in different environmental conditions might challenge cognitive abilities in different ways (e.g., Conant et al. 2003; Reyes-García et al. 2016; Sabiniewicz and Sorokowski 2017). Studies have shown that more frequent usage of a cognitive ability increases that ability. For example, African adolescents living in a culture with a tradition of orally transmitted knowledge recalled orally transmitted stories better than US-American adolescents (Rogoff 1990). Likewise, unschooled Aboriginal children from Australia, whose survival is often dependent on the ability to find a water source or a way home through the desert, were better than their Anglo-Australian peers at remembering the locations of objects (Kearins 1981).

However, the majority of studies on training to improve cognitive abilities have been conducted in contemporary societies (Broadley and MacDonald 1993; Cohen 1982; Dwyer and McKenzie 1994; Olesen et al. 2003). For example, the retention of information in LTM has been proven to be dependent on repetition (Bailey et al. 1996). STM training has brought positive results for children with down syndrome (Broadley and MacDonald 1993) and children with developmental delays (Cohen 1982). In the light of neurological

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evidence, Broadbent et al. (2004) found that a decrease in hippocampus size caused impairment of spatial memory. On the other hand, practicing working memory tasks induced an increase in cortical activity (Olesen et al. 2003). These results might suggest that different cognitive abilities develop when used under different environmental circumstances.

STM appears to be an effective tool for storing information for a short time (Baddeley et al. 1975). Thus, this kind of memory seems to be especially important for contemporary industrialized populations, as it is related to the increasing speed of people's performance in general and technological developments (Gleick 1999). According to Gleick (1999), people nowadays try to interact with machines, which includes processing a variety of short information in a few seconds, such as mobile phone access codes, bank account passwords, and individual codes given by a state. These activities, together with constant information exchange, might work as a form of training to support short memory improvement.

Whereas STM appears to be more efficient in the above-described tasks, LTM might be more useful in conditions that are typical among traditional populations. Because repetitive activities, such as shifting cultivation, hunting, and growing plants and vegetables (see Koch 1974) are an important part of the lifestyle of traditional populations, knowledge of how to perform them must be transferred from one generation to the next. Oral transmission appears to be the most common way to share this kind of information and at the same time seems to support LTM development (Rowcliffe 2004; Rubin 1977). For example, the Yora from Peru in South America evaluate plant medicines using all of the senses: taste, smell, sight, touch, and sound, which possibly serves a mnemonic function to facilitate the memorization and retention of information in the oral tradition (Shepard Jr 2004). Both common knowledge (e.g., food acquisition, interpersonal matters, responses to rare and challenging events) and knowledge related to healing abilities, such as the locations of plant medicines (Shepard Jr 2004), are spread by oral stories (see Shepard Jr 2004). Thus, oral transmission appears to be necessary for the survival of traditional populations. Likewise, knowledge related to traditions such as stories (see Huanca 2006) and social activities (Koch 1974) is based on oral transmission.

It is worth noting that in pre-industrial settings, elders appear to be a source of the knowledge contained in oral transmission owing to their age and experience. In fact, traditional societies seem to hold older adults in higher esteem than contemporary and industrialized populations (e.g., Cowgill 1986; Eyetsemitan 2002; Slater 1964). For example, Sorokowski et al. (2017) investigated attitudes toward aging in traditional (Tsimane in Bolivia) and contemporary (US and Poland) societies. The Tsimane reported more positive aging perceptions than the other two samples. Expectations about cognitive aging were also more positive, as perceptions of older adults' memory performance were most favorable among the Tsimane (Sorokowski et al. 2017). These results seem to confirm the importance of older people's memories in traditional societies.

In industrialized culture, there is a common belief, reflected in stereotypes, concerning the negative association of aging with cognitive attributes such as forgetfulness (e.g., Hummert et al. 1994). At the same time, the social context, including culturally shared beliefs, may influence memory performance through the individual internalization of age-relevant beliefs (for a review, see Hess 2005). For example, memory failures in elders are more likely to be perceived as a reflection of mental difficulty than are the same failures in younger adults (e.g., Erber and Rothberg 1991). Possibly as a result of these stereotypes, older adults have lower self-efficacy beliefs about their memory than younger or middle-aged adults (e.g., Berry and West 1993; Gilewski et al. 1990; Hultsch et al. 1987; Rebok and Balcerak 1989; West et al. 1996; for a review, see Hess 2005). Furthermore, stereotyping has a stronger impact on people with a higher level of education (Hess et al. 2009).

Hence, the development of civilization, followed by increasing literacy and the invention of print, seems to have brought about a decline both in the role of elders in the transmission of cultural traditions and history and of oral transmission itself (see Sorokowski et al. 2017), which has resulted in negative stereotypes about elders. Acculturation affects a variety of life's aspects of people from traditional populations (Godoy et al. 1998, 2007). The importance of oral transmission also appears to be related to the level of illiteracy among traditional societies (Goody 1987, but see Orange 1990). In fact, increasing access to schooling has been found to be related to loss of local knowledge, including self-treatment with herbal remedies and the use of traditional healers (see Vandebroek et al. 2011). It is possible, therefore, that increasing access to formal education is also a reason for the loss of oral transmission and thus the decrease in LTM.

Conversely, a line of evidence shows the opposite relation (e.g., Carlsson et al. 2015; Mühlenweg et al. 2012; Zahodne et al. 2011). Literacy influences different areas of cognitive functioning (Ardila et al. 2010). Learning to read and write affects both memory strategies (Laboratory of Comparative Human Cognition 1983) and several kinds of memory: verbal, visual, working memory, and phonological STM skills (Conti-Ramsden and Durkin 2007; for review, see Ardila et al. 2010). However, literacy does not seem to affect all types of memory, as neither object memory (e.g., Folia and Kosmidis 2003) nor wordlist recognition memory was found to be related to literacy level (Ardila et al. 1989).

To date, the majority of studies that have addressed the problem of environment-dependent differences in memory have been conducted on children or adolescents and overlooked the distinction between the two very basic types of memory: STM and LTM. To the best of our knowledge, the

study by Wagner (1974) is the only one to have investigated STM differences related to distinct surroundings. He examined urban and rural inhabitants of Yucatan. Life conditions for the two groups of participants were completely different: the urban sample lived in Merida, the largest city in the state of Yucatan, while rural participants lived in the town of Mayapan, without electricity or running water, and generally accessible only on foot or horseback. The results showed that urban participants performed better in STM tasks than rural participants. This conclusion was confirmed in his next study conducted in Morocco (Wagner 1978). Nevertheless, LTM has not yet been investigated in a cross-cultural study.

We decided to compare two populations living in totally different environments to understand whether the variable conditions affected their memory performance. Because people living in traditional populations seem to rely more on LTM-related skills, such as memorizing the properties of plant medicines (Shepard Jr 2004), their LTM performance might be higher than that of people from industrialized populations. Conversely, people in industrialized societies generally engage more in a variety of activities that include processing a lot of information in a short time (Gleick 1999), which might positively affect their STM performance. The purpose of this study was to investigate whether different life conditions lead to differences in STM and LTM performances in these populations.

Method

Participants

We conducted our study in an indigenous population (Papua, an Indonesian province, also known as West Papua or Irian Jaya) and a contemporary population (Poland).

The participants were volunteers: 62 were from Papua (34 men and 28 women), aged 17–75 ($M = 28.15$, SD = 13.31) and 134 from Poland (54 men and 80 women), aged 17–81 ($M = 30.72$, SD = 17.63).

Dani participants were recruited from small villages around Wamena (Baliem Valley, West Papua, Indonesia. Research in this area has been also widely described in other papers see, e.g., Groh (2016). The Indonesian research assistant informed inhabitants of the villages about the possibility of taking part in our study. Then, the information about the study was passed from mouth to mouth. In turn, Polish participants were recruited in Wroclaw (Poland) by research assistants, who spread the news about the study in many places, mostly among groups without higher education (e.g., technical workers at the University of Wroclaw, and employees of small companies in Wroclaw).

Measures and procedure

The questionnaire used in this study is described below. To test LTM, we used a short story based on everyday activities (going to a market) typical for both populations. Stories shaped as oral tales or supported additionally with pictures are typically used to measure LTM (e.g., Cahill et al. 1994, 2004; Heuer and Reisberg 1990).

> A 23-year-old man wakes up just after sunrise. He eats breakfast. After eating he drinks two cups of water and goes out. It is raining very heavily outside. The man takes a walk to a market to buy some food and, as he wants to take the shortest way to get there, he turns left from his home. Then he turns right twice and finally he reaches the place. He buys seven bananas, two pineapples, and four oranges. While walking through the market he meets a friend and they talk for a while. His friend invites him to visit his place tomorrow. After that the man decides to go back home.

The first version of the questionnaire was prepared in English and then translated into Polish and Dani. To verify the translations, the questionnaire was back-translated by two people who knew both Dani and English and Polish and English. Interpreters were native Dani with good knowledge of English. As a result, in Papua, the study was conducted in Dani and in Poland in Polish. The national identity of the participants was confirmed by the interpreter who was able to verify it linguistically. The national identity of the interpreter, in turn, raised no doubts as he had a deep knowledge of Dani's cultural background and had collaborated with the researchers also in case of previous studies.

The story was presented orally to the individual participants by the interpreter. Participants were then asked to recall the story after about 15 min (Baddeley et al. 2009; Cahill et al. 2004; Rumelhart 1975) by answering nine questions about the details of the story presented by the researcher. The instruction was the same for Polish and Dani participants. Both the story and the questions were constructed to make the content appropriate and understandable for Polish and Dani participants (e.g., kind of fruit; type of presented activity). The questions were as follows: *Is the man 22 years old? Does the man eat breakfast? Does the man drink anything in the morning? Is it sunny outside? Does the man turn right after going home? Does the man go to the market to buy some clothes? Does the man buy 5 bananas? Does the man buy 2 pineapples? Does the man's friend invite him to visit his place this afternoon?*

One point was awarded for each correct answer; thus, the maximum score was nine.

To investigate STM, we used a task based on the Wechsler Digit Span Forward test (WAIS IV; Wechsler 2008). However, we created a version of the task using face parts

instead of digits: the sequences of numbers were replaced with sequences of human face parts (e.g., the first sequence: (1) *Mouth*; the second sequence: (2) *Nose–mouth*; the third sequence: (3) *Eye–chin–chin*, and so on up to nine sequences). This change was made because human face parts are universal all over the world. According to the original procedure, participants were asked to repeat the sequences immediately after the researcher finished reading and in the same order. The maximum score was nine, one point for each sequence. The investigation in the case of Dani participants was carried out with the highest standards of ethics and attention due to avoid the slightest risk to destabilize indigenous culture. Thus, the research has been carried out in a minimally invasive way and where necessary, rescue work has been applied to enhance cultural sustainability.

Describing further the practical aspect of the research procedures, it should be underlined that Dani participants' cultural identity was not influenced in any way by the current study. Researchers were behaving with all respect to the integrity of Dani's culture and traditions. The interpreter and guide who helped in the current study were Dani and were personally known to many participants. Gifts that were offered to Dani participants were not invasive for their culture. For example, gadgets from industrial countries were not used, neither were cigarettes to follow ethical standards. Furthermore, the place where the study was conducted is visited by tourists, so Dani participants were not bothered seeing a person from another culture. Eventually, the concept of the study was constructed to not insert information or objects that could destabilize indigenous culture. For example, in the study, questions about parts of faces or fruits were used.

The final score for both tasks was computed as the sum of the points obtained in LTM (max. 9) and the STM task (max. 9).

The study was conducted according to the principles expressed in the Declaration of Helsinki and the UN Declaration on the Rights of Indigenous Peoples. The study protocol and consent procedure received ethical approval from the appropriate Institutional Review Board. Participants provided informed consent before being included in the study and were notified that they could quit the study at any time.

Results

Table 1 presents the descriptive statistics and intercorrelations between the main study variables separately for participants from Poland (upper diagonal) and Dani (below the diagonal). Participants from Poland obtained significantly higher scores for both LTM ($F(1,194) = 7.26$, $p = 0.008$, Cohen's $d = 0.41$, 95% CI 0.14–0.91) and STM ($F(1,194) = 70.10$, $p < 0.001$, Cohen's $d = 1.29$, 95% CI 1.14–1.85) (Figs. 1 and 2). The difference for STM in particular was large. Importantly, a subsequent MANCOVA with gender and age as covariates confirmed that these differences were not caused by slight differences in age and sex distribution among the participants. Age and sex were included in the analyses due to their potential impact on memory performance (Mann et al. 1990; Poon 1985).

Table 1 shows that in the Polish sample, LTM was negatively correlated with participants' age ($r = -0.22$, $p = 0.01$), but this relationship was not statistically significant among participants from Papua ($r = -0.11$, $p = 0.41$). A similar, although not significant, the pattern was observed in the case of STM: in Poland, there was a trend toward a negative association between STM and age ($r = -0.15$, $p = 0.09$), whereas no relationship was found in the case of Papua ($r = -0.02$, $p = 0.86$). The additional analysis did not demonstrate a significant interaction effect of age and culture in either case ($p = 0.57$ for LTM and $p = 0.45$ for STM), so obtained correlations did not differ from each other. As the limited sample size of this investigation raises some issues with statistical power, we calculated the Bayes factor for the obtained correlation between LTM and age separately for Poland and Papua. In the case of Poland, $BF_{10} = 5.33$, indicating strong support for the negative link between LTM and age (five times more likely than the null), while in the case of Papua, $BF_{10} = 0.35$ ($BF_{01} = 2.84$), hence providing weak (anecdotal) support for the null hypothesis and confirming the lack of a relationship between LTM and age.

Discussion

The results of our study suggest the existence of significant differences in STM and LTM between Polish and Dani

Table 1 Descriptive statistics and intercorrelations between the study's variables

	Poland M (SD)	Sex	Age	LTM	STM
Sex	60% F	1	0.14	0.13	− 0.06
Age	30.72 (17.63)	− 0.03	1	− 0.22*	− 0.15^
LTM	7.06 (1.34)	0.24^	− 0.11	1	− 0.032
STM	5.19 (1.29	0.11	− 0.02	0.43**	1
Papua M (SD)	–	45% F	28.15 (16.40)	6.53 (1.11)	3.69 (0.80)

Poland $n = 134$, Papua, $n = 62$. Correlations for Poland are presented above the diagonal, correlations for Papua—below the diagonal. ^$p < 0.10$; *$p < 0.05$; **$p < 0.01$

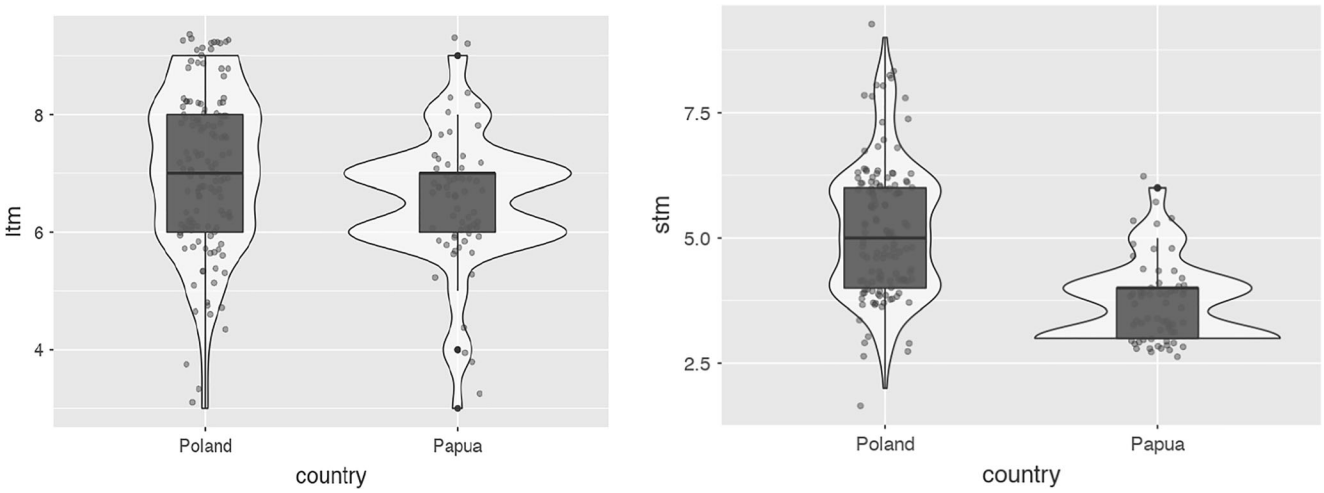

Fig. 1 Differences in LTM (left panel) and STM (right panel) between Poland and Papua

populations. Polish participants performed better on both tasks, but especially on the STM task. The culture was not a significant moderator of the age-related memory differences in the two populations.

The majority of research on cognitive abilities has been conducted in industrialized societies (e.g., Carlsson et al. 2015; Morrison and Chein 2011; Mühlenweg et al. 2012; Zahodne et al. 2011), whereas investigating the subject in traditional societies might generate important results. The lifestyles of participants in indigenous societies might be considered as similar to those of societies before present industrialized societies. Some studies on cognitive abilities in traditional populations (e.g., Cashdan and Gaulin 2016; Cashdan et al. 2012; Kolling et al. 2016; Reyes-García et al. 2016; Sabiniewicz and Sorokowski 2017; Silverman et al. 2007; Sjoberg et al. 2014; Trumble et al. 2015; Vashro and Cashdan 2015) seem to suggest the existence of evolutionary and historical changes in cognitive abilities.

The obtained differences in STM performance are in line with the study by Wagner (1974), who explained his results in terms of the level of schooling. Current studies also support the thesis that formal education and the acquirement of school-related skills significantly affect some cognitive and non-cognitive skills (e.g., Carlsson et al. 2015; Mühlenweg et al. 2012; Zahodne et al. 2011). First, STM seems to be more extensively used by people in industrialized societies as a result of technical developments and the electronic revolution (e.g., Gleick 1999). Likewise, fast information exchange is another source of materials to be processed by STM. Third, because the reading ability is related to STM measures (Swanson et al. 2009) and is often practiced by people in globalized societies, reading performance can increase STM performance.

It was observed that participants from Poland also obtained significantly higher LTM scores. Our study is the first to demonstrate this effect and all its limitations should be considered. The scales used to investigate STM and LTM were restricted

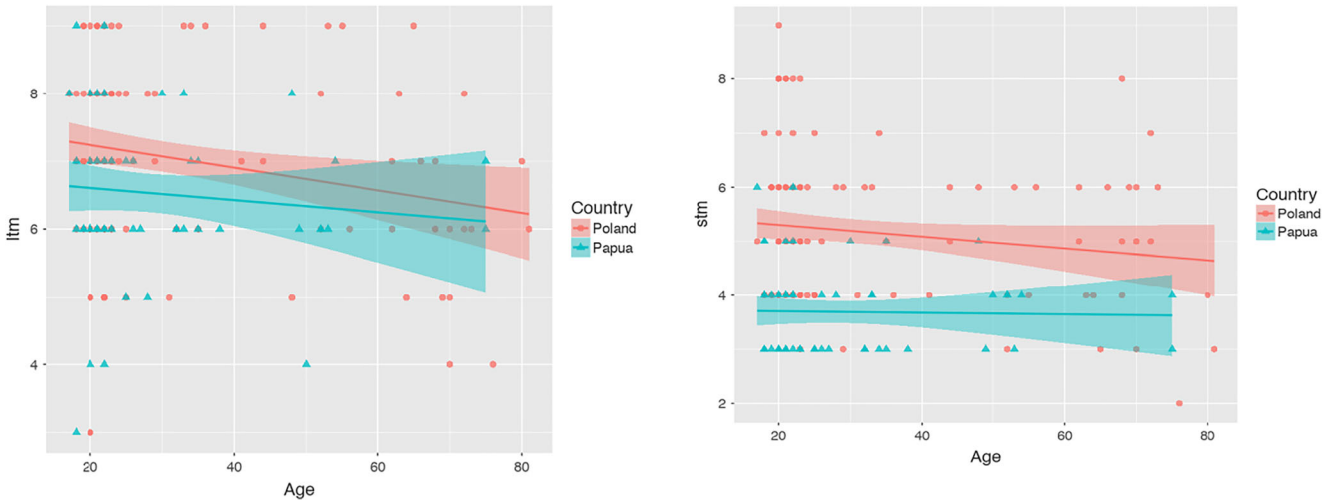

Fig. 2 The relationships between age and LTM (left panel) and STM (right panel) in Poland and Papua

to 10 points, while using measures with a greater range of variability could offer more insights into the nature of the differences between these kinds of memory. Therefore, we suggest that further studies are necessary to clarify this issue. Further research might also include investigating environmental conditions in the same country, STM and LTM and employing a between comparison with refugee migrants that have recently arrived in a new country and former refugee families from the same country that have lived in the host country for more than one generation.

The participants' culture did not significantly moderate the relationships between LTM, STM, and age in either country. Our study is the first to investigate age differences in memory in a traditional and industrialized population. In industrialized countries, interest in the relationship between aging and memory performance has resulted in a rich literature suggesting that memory declines with age (see Crook and Ferris 2006). This impairment is suggested to be due to biological and social factors (see Hess 2005, for a review) such as stereotypes. While negative age stereotypes have a negative influence on memory, positive age stereotypes have a positive influence (Levy 1996; O'Brien and Hummert 2006).

Several studies have investigated this relationship by comparing cultures with varying attitudes toward elders (see Gutchess and Boduroglu 2015; Sorokowski et al. 2017). Levy and Langer (1994) found that both older Chinese and deaf American participants outperformed the older American hearing group, whereas young adults from these cultures performed at the same level. Furthermore, different views toward aging were reflected in the participants' scores, thus supporting the assumption that memory decline might be due not only to biological but also to social psychological mechanisms (Levy and Langer 1994). In contrast, these results were not confirmed by Yoon et al. (2000), who demonstrated that younger adults, regardless of their culture, performed better than older adults on all memory tasks (see also Levy 1996). Furthermore, the effect of culture appeared to be much weaker than the effect of age. The authors concluded that it is age rather than a culture that plays a crucial role in memory performance (Yoon et al. 2000).

Our obtained results seem to be in line with this conclusion. Even though attitudes toward older people appear to be more positive in traditional than in contemporary societies (Cowgill 1986; Eyetsemitan 2002; Slater 1964; Sorokowski et al. 2017), we found no age differences in memory performance between populations. Considering the abovementioned disparities in the attitude toward elders between the two investigated populations, the results of our study seem to underline the crucial role of age in the memory performance.

To conclude, different environmental conditions challenge human senses and cognitive abilities in different ways (e.g., Shepard Jr 1992, 2004; Sorokowska et al. 2013). In this study, we showed that both STM and LTM vary in two populations living in totally different environments. Thus, our results seem to indicate that both STM and LTM might be dependent on different environmental conditions.

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Compliance with ethical standards

The study was conducted according to the principles expressed in the Declaration of Helsinki and the UN Declaration on the Rights of Indigenous Peoples. The study protocol and consent procedure received ethical approval from the appropriate Institutional Review Board.

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