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Developing the Japanese and English versions of the Mind Blanking Questionnaire (MBQ): validation and reliability☆

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ABSTRACT

We occasionally experience moments when our minds go blank, or our attention disappears. This psychological phenomenon, known as mind blanking (MB), has recently garnered increased attention. MB has been assessed at the state level using experience sampling methods in which participants undertake a cognitive task and probes suddenly appear asking them to report the current contents of their thoughts. However, it may be possible to evaluate MB at the "trait level" as is the case with other mental states (e.g., mind wandering, anxiety, and the like). In the present study, we developed a new scale, the Mind Blanking Questionnaire (MBQ), for assessing the tendency of MB at the trait level in both Japanese and English. The MBQ exhibited good psychometric properties including internal consistency, test-retest reliability, and criterion and construct validities. Additionally, it displayed measurement invariance between the language versions, genders, and age groups. The MBQ would be a valuable tool to assess the individual tendency of MB and contribute to cross-cultural studies.

1. Introduction

Our minds wander from the present moment to the past or the future. This is a natural and normal human experience, and it can happen at any time, without intention or awareness, even when trying to focus on something else. This phenomenon was called mind wandering (MW) and has been the subject of much research (McVay & Kane, 2010; Robison et al., 2020; Schooler et al., 2004; Smallwood & Schooler, 2006).

MW can be assessed in both "state" and "trait" dimensions. A great deal of research has assessed state MW using behavioral tasks, such as the sustained attention to response task (similar to a prolonged go/no-go task), employing an experience sampling method in which probes suddenly appeared asking participants to report the current content of their thoughts during the task (Robison et al., 2020; Schooler et al., 2004). At the same time, the tendency for MW can also be measured with a questionnaire. The most well-known MW questionnaire is the Mind Wandering Questionnaire (MWQ), composed of 5 items on a single factor (Mrazek et al., 2013). This questionnaire asks, similarly to other psychological questionnaires, to what extent the subject's mind wanders in daily life, which is the trait tendency for MW. While trait-state association in MW does not seem to be high [$|r|s = 0.2$–0.3; (Kawagoe et al., 2020; Mrazek et al., 2013; Seli et al., 2016)], this is similar to findings for other comparable (neuro)psychological concepts, such as executive function, for which the trait-state association has been under debate (Dang et al., 2020).

At other times, our mind may wander "nowhere," that is, we sometimes experience moments when our minds go blank, or our attention simply disappears. A decade ago, Ward and Wegner (2013) stimulated research on this topic, naming this phenomenon "mind blanking" (MB), and defining it as a lack of conscious awareness. Although several previous studies reported or suggested such psychological phenomenon (Schooler et al., 2004; Watts et al., 1988; Watts & Sharrock, 1985), until Ward and Wegner (2013) empirical studies had not focused on it due to the elusive nature of MB (e.g., "how can one simulate an absence?" and "how can one remember nothing?" [p. 2]). Although it varies depending on the study, behavioral evidence has indicated that people report MB

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approximately 3 % (Mortaheb et al., 2022), 6 % (Van Calster et al., 2017), and 15 % (Ward & Wegner, 2013) of the time when requested to self-evaluate their mental state during focused task or resting-state sessions. Using several techniques pioneered in the MW literature, Ward and Wegner (2013) empirically demonstrated the existence of MB and its phenomenological and behavioral independencies from MW, a seemingly similar construct in the sense of losing attentive focus. Since their report, several studies have focused on or considered MB (Andrillon et al., 2021; Kawagoe et al., 2019; Robison et al., 2020), outlining important features of MB such as its clinical characteristics. For example, Van den Driessche et al. (2017) reported that attention-deficit/hyperactivity disorder (ADHD) patients reported more MB than clinical control patients or healthy control participants during a standard go/no-go task. Notably, methylphenidate treatment was associated with a significant reduction in MB reports in ADHD patients, bringing them to the level of the healthy control group. Studies have investigated the neuroscientific characteristics of MB as well. Kawagoe et al. (2019) first reported the neural correlates of MB, degraded activations of Broca's area and the hippocampus, via functional MRI (fMRI), although they made it possible to assess MB by asking participants to deliberately "think of nothing" as MB rarely occurs. A recent study targeting a more natural MB state via almost one-hour fMRI scanning has reported that the MB state is associated with all brain regions communicating with each other as if in deep sleep (Mortaheb et al., 2022).

The above studies assessed "state" MB using behavioral tasks with an experience sampling method. However, to our knowledge, no study has focused on the "trait" tendency of MB. Considering the clinical significance of MB, a means of assessing trait MB is needed to aid in uncovering the psychological and neural characteristics of MB, as well as the mechanisms underlying this phenomenon. Such a measure would not only help to distinguish its state and trait characteristics, further elaborating the MB construct, but also be useful for exploring associations between MB and psychological traits, providing clues for understanding our consciousness and thinking.

The conception of MB that frames this study comprises three major components: (a) MB is a moment without conscious awareness (Ward & Wegner, 2013), signifying a moment devoid of sensory or bodily perceptions, or any form of thought; (b) it remains independent of states of unconsciousness such as those brought about by anesthesia, epilepsy or absence seizures; and (c) the experience of MB typically lasts from only several seconds to a few tens of seconds. These bases are similar to findings from previous studies. Ward and Wegner (2013) defined MB as "a lack of conscious awareness" (p. 1) and Andrillon et al. (2021) characterized the phenomenon of MB as "the stream of thoughts can come to a pause when individuals who are awake are left with a feeling of an empty mind" (p. 2) (a), without referring to pathological phenomena (b). Fell (2022) noted that the absence of thought (i.e., MB; although he proposed that it be called *thought blanking*) can happen in a non-pathological waking state, much like the phenomena of attentional blink or a meditator's experience of emptiness (b). Furthermore, most experimental studies have assessed state level MB using an experience sampling method (i.e., participants are stopped during a task, presented with a thought probe, and asked to choose the appropriate option to describe one's thought at the time immediately before the probe) with, in most cases, a relatively low-demand but long-lasting task (Van Calster et al., 2017; Van den Driessche et al., 2017; Ward & Wegner, 2013). This is based on the assumption that the MB is temporally similar to attentional lapse or MW which occurs on the second timescale (c).

In this study, we have developed the Mind Blanking Questionnaire (MBQ) based on the theoretical conception described above. We conducted two surveys for cross-cultural utilization. First, the Japanese (four authors' first language) version of MBQ was created, then we translated it into English, and went through a validation process including, as well as gender and age group invariance. Our results indicate that the MBQ can be a useful tool to assess individual tendencies for MB at the trait level. As the concepts informing the MBQ align with the consensus of research into MB, we expect that the MBQ will be applicable in a range of studies.

2. Materials and methods

2.1. Participants

The primary Japanese sample was collected via a data collection agency (iBRIDGE Corporation: https://freeasy24.research-plus.net/). For the survey, a sample size of 384 was needed to obtain the desired accuracy with a confidence interval (CI) of 95 % for the large population size (>250,000; Taherdoost, 2017). To assure this sample size, we requested 500 participants with ages ranging from 20 to 59, and who were thought naïve to the concept of MB. To find and exclude the participants who adopted satisficing behavior (Krosnick, 1991), we incorporated several lure items (e.g., *Please check the rightmost choice for this question.*). Among the 500 participants, 120 participants (24 %) were excluded because they did not pass the lure items, leaving a sample size of 380 for analysis (mean age: 46.8 [SD: 9.6]; 192 women).

Native English speakers were also recruited via a data collection agency (Cross Marketing Inc.: https://www.cross-m.co.jp/en/). Participants were living in the U.S. when the survey was conducted. Before the survey, participants were asked to describe their English skill and only those who chose the option *I'm a native speaker of English so I have no problem understanding* instead of *It requires some effort to understand English because I'm not a native speaker* were able to proceed to the survey. Similar to the Japanese sample, we requested 500 participants with ages from 20 to 59 and included lure items to uncover participants who adopted satisficing behavior. This resulted in 179 participants (36 %) being excluded, leaving a sample size of 321 for analysis (mean age: 41.3 [SD: 11]; 179 women).

Additionally, test-retest reliability was assessed with at least a 2-week (up to 4-week) interval using an independent sample of Japanese university students. The collected sample size for pre- and post-surveys were 323 and 307, respectively. From these, 241 individuals participated in both surveys. The two lure items detected 21 participants who adopted satisficing behaviors, leaving a sample size of 220 for analysis (mean age = 19.0 [SD = 1.1], 125 women). Informed consent was received from all participants in this study. The study protocol was approved by the institutional review board of Tokai University (No. 23068).

2.2. Development of Japanese version of mind-blanking questionnaire

To develop the MBQ, we first consulted a well-known scale for MW, the MWQ (Mrazek et al., 2013). The MWQ was developed based on three existing questionnaires from which the authors extracted items. As a result, five items asking about an inability to focus attention, partly due to thinking about something else, were selected and validated. Each item describes specific situations or conditions such as *simple or repetitive work*, *while reading*, *listening*, or *during lectures* (Mrazek et al., 2013). Thus, as our first step in developing the MBQ, we aimed to determine situations or conditions in which respondents experienced MB in their daily life by collecting data from 122 university students (mean age: 20.7 [SD: 0.6]; 55 women) who provided free descriptive answers to the question *Do you ever have moments when your mind goes blank in your daily life (*e.g.*, during reading, watching movies, taking a walk, or taking a train)? If so, what are the circumstances, and what do you experience during those moments?* Two of the authors (TK and KO) independently coded the responses using the KJ method (Scupin, 1997). The results of the coding process were similar between the two authors and indicated that respondents had difficulty specifying such situations or conditions. All authors then discussed the results and concluded that people were unable to report specific situations or conditions in which they experience MB because of the infrequent nature of MB. As a result, we decided to develop items for the MBQ based on the theoretical conception of MB described above.

As the next step, we devised sentences in Japanese to describe MB. In the MWQ, the inability to focus attention or losing attention due to MW is described using various wordings such as *I have difficulty maintaining focus on…*, *…I find I haven't been thinking about…*, *I do things without paying full attention*, and *I mind-wander…*, which consequently resulted in a single factor (Mrazek et al., 2013). In devising sentences to describe MB, four of the authors (TK, SY, SM, and KO) independently developed as many expressions describing MB as possible with the result that we produced, to a great extent, sentences similar to each other. Through discussion, we determined eight items that adhered most closely to the consensus for the basic concepts of MB, comprising the tentative MBQ (at this point, all the items were in Japanese; the English version is shown in Table 1). The MBQ employs a 6-point Likert scale, following the MWQ, in which a higher score indicates higher tendency of MB.

2.3. English translation of the mind-blanking questionnaire

This process comprised three phases: translation, back-translation, and evaluation. The Japanese authors (TK, SY, SM, and KO) whose second language is English first translated the Japanese version of the MBQ into English collaboratively. This version was then back-translated by a bilingual author (LX) who has a background in testing and scale development and was naïve to the MBQ. The back-translated items were checked by the four Japanese authors and evaluated for their equivalence to the original. The process was repeated until consensus was reached among all authors.

2.4. Measures for validation

For the validation process, several measures, including questionnaires for MW, executive function, mindfulness, sleepiness, and depression, were administered. These psychological constructs were chosen as they were hypothesized to be, or not be, related to MB. The respective rationales are described below in the section describing each index, and in all cases, measures were administered in participants' native language.

2.4.1. Mind Wandering Questionnaire (MWQ)

The MWQ is a single-factor questionnaire that assesses an individual's tendency towards MW with five items, using a 6-point Likert scale, and total score ranging from 5 to 30, with higher scores indicating higher levels of MW tendency (Mrazek et al., 2013). Although the MBQ was based on the MWQ, which would suggest a degree of correlation between the two, MW and MB are reported to be partly independent constructs as described above (Ward & Wegner, 2013). For these reasons, the discriminant validity of the two was also investigated. The Japanese version of the scale used in this study was that of Kajimura and Nomura (2016).

Table 1
Items of the initial version of Mind Blanking Questionnaire (MBQ) in English.

No.	Items
1	I suddenly realize I haven't been thinking about anything.
2	There are times when I realize that my mind is empty.
3	**There are moments that I can't remember what I was just thinking about.**
4	**There are times when my mind goes completely blank.**
5	**I have times where I just space out without thinking about anything.**
6	**I find myself not knowing what I was doing even though I wasn't thinking about anything else.**
7	**There are moments when my mind empties out.**
8	I find myself staring into space without any thoughts.

Note. Although the Japanese items were developed initially, the translated English items are listed here for reference. Items in bold were retained in the final version of the MBQ (5 items).

2.4.2. Effortful Control Scale (ECS)

The ECS (Yamagata et al., 2005) derived from the Adult Temperament Questionnaire (Rothbart et al., 2000) was administered to measure participants' executive function (EF). Effortful control is defined as the ability to use attentional resources and inhibit behavioral reactions to regulate emotions and related behaviors. It is conceptually similar to EF, a top-down mental process composed of inhibitory control, working memory, and cognitive flexibility (Diamond, 2013). The ECS includes components measuring active suppression of activity (i.e., inhibitory control), initiation of behavior even when not motivated (i.e., activation control), and voluntary focusing or shifting attention (i.e., attentional control). Scores range from 11 to 77 for the inhibitory control component and from 12 to 84 for both the activation control and attentional control components, with higher scores indicating greater EF. As there is no English version of ECS, we utilized the corresponding items from the Adult Temperament Questionnaire with U.S. participants.

EF has been reported to be a fundamental mechanism behind the occurrence of MW (McVay & Kane, 2010; Smallwood & Schooler, 2006). Notably, in trait levels, a negative correlation between MW and EF has been observed (Kawagoe, 2022; Kawagoe et al., 2020; Unsworth & McMillan, 2013). We included the ECS in the survey to understand differences in EF's association with MW and MB and to support the construct validity of the MBQ. Specifically, we expected a negative correlation between MB and EF as the occurrence of MB might be a result of failure in the control of executive resources to keep attention on the current task, similar to findings with regards to MW (Kane & McVay, 2012; Kawagoe, 2022; McVay & Kane, 2010).

2.4.3. Epworth Sleepiness Scale (ESS)

The ESS is a widely used subjective measure of a rater's sleepiness (Johns, 1991), with total scores ranging from 0 to 24, and higher scores indicating greater sleepiness in daily life. As noted above, functional brain connections during MB are reported to be similar to those during deep sleep (Mortaheb et al., 2022). Other studies have shown that sleep-like brain activation such as localized slow waves can be found during MB and MW, and lead to an increase in task errors (Andrillon et al., 2021; Bernardi et al., 2015). However, since the measures in the current study assess not state but trait phenomena, there should be some independence between the indices for MBQ and ESS. To our knowledge, there is no evidence for an association between sleepiness and MB at the trait level. Alternatively, if there is a deep relationship, one could speculate that the MBQ assesses sleepiness rather than MB itself. Thus, we employed sleepiness to assess concurrent validity, and to clarify the independence of MB, MW, and sleepiness. The Japanese version of the ESS was that of Takegami et al. (2009).

2.4.4. Mindful Attention Awareness Scale (MAAS)

Mindfulness, that is remaining attentive and aware of events and experiences occurring in the present moment without cognitive and emotional processing, can be assessed with the MAAS (Brown & Ryan, 2003). As conceived in the MAAS, the core components of mindfulness are attention and awareness. The mindful person is able to maintain attention on and awareness of the present situation, and thus, mindfulness and MW appear to be opposing constructs, which has been empirically verified (Mrazek et al., 2012). The measure for mindfulness will provide additional information to validate the MBQ, i.e., a negative relationship between mindfulness and MB is hypothesized. Total scores on the MAAS range from 15 to 90, with higher scores indicating higher levels of mindfulness. Japanese version of the MAAS was used with the Japanese sample (Fujino et al., 2015).

2.4.5. Patient Health Questionnaire-9 (PHQ-9)

Although MB is a rare psychological phenomenon in healthy adults as described above, Watts and Sharrock (1985) reported that one-third of depressive patients *usually* or *always* experience MB before experiencing lapses in concentration in their daily lives. Later, Watts et al.

(1988) reported that depressive subjects who are prone to MB performed worse in a complex planning task (i.e., the Tower of London task). Thus, one could expect that the occurrence of MB is associated with depression. We assessed this relationship to determine convergent validity using the PHQ-9, which assesses depression with half the number of items as many other depression measures (Kroenke et al., 2001). The PHQ-9 instructs individuals to assess the frequency of specific depression symptoms they've experienced in the past two weeks, using a four-point scale that ranges from *not at all* to *most days*. The possible range is from 0 to 27, and higher scores indicate greater depression.

2.5. Analysis

After completing the data cleaning process (outlined in Section 2.1), our initial analysis focused on the item level adequacy of the MBQ in both the Japanese and U.S. datasets. We generated histograms to visualize the distribution of data and to assess the presence of floor (mean value minus 1SD less than the minimum value of 1) and ceiling (mean value plus 1SD exceeding the maximum value of 6) effects. Internal consistency was assessed via Cronbach's α, and McDonald's ω_h, and ω_t.

Data suitability for factor analyses was ascertained using the Kaiser-Meyer-Olkin test. Determination of the number of factors to extract was based on a range of criteria, including Kaiser's criterion (factors with eigenvalues exceeding 1 should be extracted), Cattell's method (the number of factors to extract determined by the elbow in the scree plot), Horn's parallel analysis with 1000 iterations, and Velicer's minimum average partial (MAP) test. For parallel analysis, Lim and Jahng (2019) recommend determining the number of factors to extract with a range of ±1 from the factors indicated together with the interpretability of the factors. Both exploratory factor analysis (EFA) and multiple group confirmatory factor analysis (MG-CFA) were conducted for validation purposes.

MG-CFA, which investigates the degree to which measurements are invariant across groups, was employed to determine the cross-cultural validity of the MBQ, as well as its gender and age invariance. Subjects with identical levels of the latent construct (i.e., MB tendency) are expected to have the same raw score. If this expectation is satisfied, the scale is said to have measurement invariance. In a structural equation modeling framework, four different levels of measurement invariance are defined: configural, weak, strong, and strict invariance models (Widaman & Reise, 2004). We will briefly describe the steps of MG-CFA following recommended best practices (Hirschfeld & Von Brachel, 2014; Putnick & Bornstein, 2016; van de Schoot et al., 2012). First, we investigated whether a baseline model, to be employed in the following steps, fit the entire dataset without considering language. Next, a configural invariance model, without any constraints on loadings, intercepts, variances, etc., was fit for each group separately. After confirming the same factorial structure held between groups, a constrained version of the configural invariance model (i.e., weak invariance model) was fit in which the factor loadings were assumed to be uniform between the groups. Then, a constrained version of the weak invariance model (i.e., strong invariance model) was fit where the item intercepts in addition to the factor loadings were constrained to be equal. This level of invariance is necessary to compare the latent mean of the scale between groups (e.g., cross-cultural comparison). Finally, a more constrained version of the strong invariance model (i.e., a strict invariance model) was fit in which factor loadings, intercepts, and residual variances were constrained to be equal. The four models were compared step-by-step in order to determine the level of invariance that could be confirmed. In deciding to accept or reject each model, a number of criteria for assessing the differences between the two nested models (e.g., weak model vs. configural model, strong model vs. weak model, and so on) were employed, a practice which has been recommended recently (Putnick & Bornstein, 2016). We adopted Chen's criteria (Chen, 2007) which includes alternative fit indices (i.e., −0.001 change in CFI, 0.015 change in RMSEA, and SRMR changes of 0.03 for weak invariance and of 0.015 for strong and strict invariance) and does not depend solely on the conventional criterion of the significance of the change in $\chi 2$ (Byrne et al., 1989). In seeking the best model, the Lagrange Multiplier test was utilized to ascertain which parameter restriction(s) were violated. The robust weighted least squares (WLSMV) method was used for estimation in both EFA and CFA to address the issue of skewed distributions, particularly relevant for the U.S. dataset, and the data were treated as continuous, given the sufficient number of response categories (i.e., 5; Rhemtulla et al., 2012).

For the correlation analyses, we adopted Spearman's ρ as some of the data were not normally distributed. Both simple and partial correlation analyses were conducted to investigate the independence of the MBQ and the MWQ. For the partial correlations, the effect of another *mind* questionnaire (i.e., the variable of the MWQ on the MBQ's correlations and the MBQ on the MWQ's correlations) was covaried out. Finally, longitudinal data were analyzed to investigate test-retest reliability, employing the intraclass correlation coefficient (ICC) using a two-way random effects model for absolute agreement (i.e., ICC[2,1]). Hommel's method was utilized as the multiple correlation correction where necessary.

3. Results

3.1. Item analysis and factor structure of the MBQ

Although we developed the Japanese version of the MBQ first, we show the English version of each in Table 1 for readers' convenience (Both Japanese and English versions are included in the Supplementary Material). As shown in Fig. 1, many items of the data from the U.S. show a right-skewed distribution. No item displayed floor or ceiling effects in the Japanese version while some items show floor effects in the English version. Interestingly, more participants from U.S. reported that they do not experience MB in daily life (i.e., scored 5 on the MBQ) than Japanese participants (U.S.: 13 %, 41 out of 321; Japan: 7 %, 32 out of 380).

The Kaiser-Meyer-Olkin test confirmed that the samples were adequate (the measure of sampling adequacy was 0.91 in both datasets). As shown by the scree plots (Fig. 2), a single factor solution was suggested for both the Japanese and U.S. data by both Kaiser's criterion and Cattell's method. Horn's parallel analysis indicated three factors for Japanese data and two factors for U.S data, while Velicer's MAP test indicated one-factor with a minimum of 0.06 for Japanese and of 0.05 for U.S. data. Taken as a whole and with consideration for the theoretical and developmental background of the MBQ, the results suggested a single factor solution for the MBQ in both languages. Internal consistency using all 8 items was good in both the Japanese ($\alpha = 0.94$, $\omega_h = 0.81$, and $\omega_t = 0.96$) and U.S. data ($\alpha = 0.94$, $\omega_h = 0.86$, and $\omega_t = 0.95$) .

3.2. Measurement invariant item selection across languages

For cross-cultural validation, we aimed to identify those items displaying measurement invariance. The sequential results of the analysis are shown in Table 2. First, a single-factor model with all 8 items was adopted as the baseline model (top row in Table 2), which fit the current combined dataset well enough. We then conducted a series of MG-CFAs. Configural and weak invariance were both confirmed with the initial 8-item model (i.e., model M1). However, the next step of the analysis was suspended due to a lack of strong invariance for model M1. We then employed the Lagrange Multiplier test to identify fixed or constrained parameters that should be released to improve the goodness of fit, specifically, constraints relating to Items 1, 8, 2, and 4 violated invariance. We then freed up those equality constraints by deleting the items one-by-one to establish cross-cultural measurement invariance, that is, when a model satisfying strict invariance between the languages was found. Models M2, M3, and M4 comprised 7 items (with the elimination of Item 1), 6 items (with the elimination of Items 1 and 8), and 5 items (with the elimination of Item 1, 8, and 2), respectively. We found that

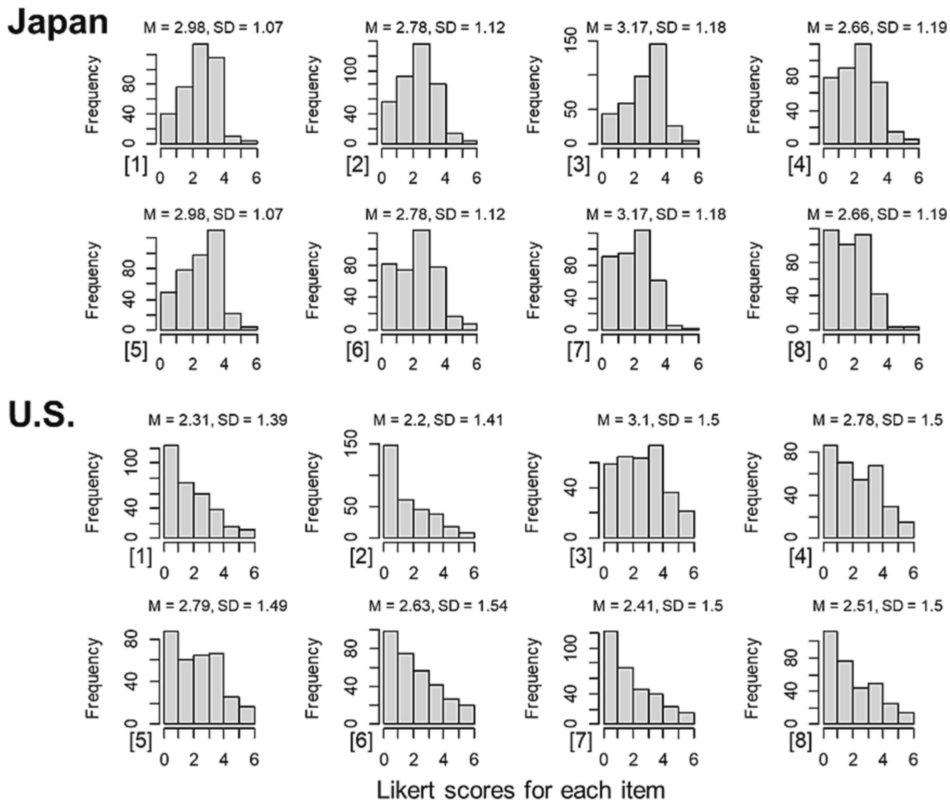

Fig. 1. Histograms with means and standard deviations for each item in the Mind Blanking Questionnaire (MBQ) in Japanese (upper panel) and English (lower panel) versions.
Note. The numeral in square brackets indicates the item number. M = mean; SD = standard deviation.

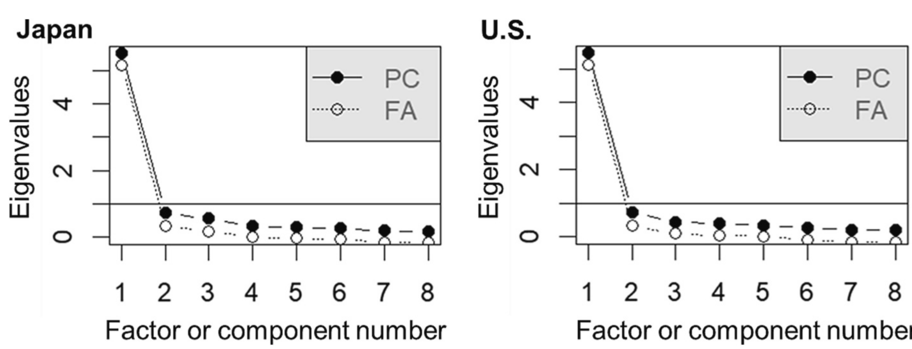

Fig. 2. Scree plots for eigenvalues for the eight principal components and factors in Japanese (left) and U.S. (right) data from the Mind Blanking Questionnaire.
Note: PC = principal component analysis; FA = factor analysis.

the 5-item model M4 possessed strict invariance between languages as shown in Table 2, and thus, the MBQ comprises the 5 items shown in bold in Table 1. This model displayed good internal consistency in both Japanese (α = 0.90, ω_h = 0.91, and ω_t = 0.92) and English versions (α = 0.90, ω_h = 0.91, and ω_t = 0.93).

3.3. Age and gender invariance of the MBQ

In addition to cultural invariance, we also investigated the invariance of the MBQ in regard to gender and age. For gender, invariance between men and women was examined. For testing age related invariance, respondents were split into two equal-sized groups, age 20–39 and age 40–59. The results indicated that the MBQ possesses strict invariance for gender and age in the current dataset, as well as for language (Table 3).

3.4. Independence of the MBQ and the MWQ

Based on their theoretical independence, we tested the independence of the MBQ from the MWQ. Spearman's ρ between them was 0.53 (95 % CI: 0.45–0.60, $p < 0.001$) in the Japanese and 0.61 in the U.S. data (95 % CI: 0.54–0.68, $p < 0.001$; Fig. 3a), indicating that there is substantial association between the constructs assessed by the MBQ and the MWQ in both languages.

Next, we used EFA to test whether there was factor structure and item level homology between the MWQ and the MBQ with a dataset including all items from each questionnaire. The scree plots (Fig. 3b) indicated that a two-factor solution would be appropriate for the datasets in both languages, following both Kaiser's criterion and Cattell's method. Velicer's MAP test also suggested a two-factor model with a minimum of 0.04 for both Japanese and U.S. datasets. BIC achieved minimum values with a three-factor solution in the Japanese (minimum

Table 2
Fit indices for each model generated in the search for measurement invariant items.

Model	[Δ] χ^2	[Δ] *df*	*p* [for $\Delta\chi^2$]	[Δ] CFI	[Δ] RMSEA	[Δ] SRMR	Decision
M1_Baseline	*185.86*	*20*	*<0.001*	*0.904*	*0.054*	*0.048*	–
M1_Configural	210.90	40	<0.001	0.900	0.054	0.046	–
M1_Weak	[7.273]	[7]	[0.401]	[<0.001]	[−0.004]	[0.003]	Accept
M1_Strong	[185.74]	[7]	[<0.001]	[0.028]*	[−0.011]	[0.02]*	Reject
M2_Baseline	*72.45*	*14*	*<0.001*	*0.960*	*0.037*	*0.034*	–
M2_Configural	109.86	28	<0.001	0.946	0.045	0.037	–
M2_Weak	[7.83]	[6]	[0.250]	[<0.001]	[−0.003]	0.004	Accept
M2_Strong	[111.84]	[6]	[<0.001]	[−0.007]	[0.024]*	[0.017]*	Reject
M3_Baseline	*48.94*	*9*	*<0.001*	*0.969*	*0.038*	*0.032*	–
M3_Configural	59.67	18	<0.001	0.967	0.039	0.030	–
M3_Weak	[4.03]	[5]	[0.545]	[<0.001]	[−0.006]	[0.003]	Accept
M3_Strong	[76.10]	[5]	[<0.001]	[−0.005]	[0.028]*	[0.018]*	Reject
M4_Baseline	*19.57*	*5*	*0.002*	*1.000*	*0.030*	*0.023*	–
M4_Configural	26.54	10	0.003	*1.000*	0.032	0.023	–
M4_Weak	[5.57]	[4]	[0.233]	[<0.001]	[−0.002]	[0.005]	Accept
M4_Strong	[16.75]	[4]	[0.002]	[<0.001]	[0.008]	[0.007]	Accept
M4_Strict	[26.77]	[5]	[<0.001]	[−0.002]	[0.011]	[0.014]	Accept

Note: Each baseline model (in italics) was tested using simple confirmatory factor analysis on the combined (Japan and U.S.) dataset, while the other models were tested with multiple group confirmatory factor analysis. Model M1 comprised eight items, and the number of items was reduced in a stepwise fashion for each subsequent model, leading to Model M4 with 5 items. The values in brackets are delta values, i.e., the difference between the current model and the nested model, with asterisks indicating the basis for rejection. *df* = Degrees of freedom; CFI = Comparative fit index; RMSEA = Root mean square error of approximation; SRMR = Standardized root mean square residual.

Table 3
Fit indices for gender and age invariance testing.

Model	[Δ] χ^2	[Δ] *df*	*p* [for $\Delta\chi^2$]	[Δ] CFI	[Δ] RMSEA	[Δ] SRMR	Decision
Gender invariance							
Baseline							–
Configural	21.41	10	0.018	0.988	0.028	0.022	–
Weak	[1.09]	[4]	[0.752]	[<0.001]	[<0.001]	[0.002]	Accept
Strong	[4.20]	[4]	[0.379]	[<0.001]	[−0.002]	[0.002]	Accept
Strict	[5.06]	[5]	[0.408]	[<0.001]	[−0.002]	[0.004]	Accept
Age invariance							
Baseline							–
Configural	26.25	10	0.003	0.985	0.033	0.023	–
Weak	[2.01]	[4]	[0.732]	[<0.001]	[−0.01]	[0.002]	Accept
Strong	[2.58]	[4]	[0.629]	[<0.001]	[−0.005]	[0.001]	Accept
Strict	[11.06]	[5]	[0.050]	[<0.001]	[0.007]	[0.007]	Accept

of −77.14) and a two-factor solution in the U.S. (minimum of −56.75) dataset. Taking the results collectively, and considering the theoretical background, we adopted a two-factor solution, the results of which clearly indicated the mutual independence of the two questionnaires (Table 4).

3.5. Correlational analyses of measures

We next analyzed the correlations between MBQ scores and other measures. Table 5 shows the descriptive statistics for each measure, including the MBQ. Only inhibitory control from the ECS differed significantly between languages after multiplicity correction ($p < 0.001$). The simple correlations of MBQ with other measures are shown in the left panel of Fig. 4a. The three measures of executive function from the ECS and the MAAS were negatively correlated with the MBQ, while the ESS and PHQ were positively correlated, all of which were consistent with our expectations. All correlations were significant ($ps < 0.001$). Although the items in the MBQ and MWQ were originally designed to represent distinct psychological constructs (i.e., MB and MW, respectively) and the EFA described above indicated this, simple correlation analysis indicated a substantial similarity between the constructs. Thus, we conducted partial correlation analyses to investigate the relationships for the MBQ in which the effect of the MWQ was partialed-out (left panel, Fig. 4b). Additionally, the simple and partial correlation coefficients of the MWQ are shown (right panels of Fig. 4a and b). All partial correlations were significant after the multiple test correction ($ps < 0.026$) except the correlation coefficients between the MBQ and inhibition in US dataset ($p = 0.129$) and between the MBQ and the ESS in both datasets ($p = 0.062$ in Japan and $p = 0.128$ in U.S. data). It is important to note that there was no great difference in the simple and partial correlation coefficients and their patterns of association between languages.

3.6. Test-retest reliability of MBQ

We also conducted a longitudinal survey to investigate the test-retest reliability of the Japanese version of the MBQ. The resulting mean interval was 20.3 days (SD: 2.1). The ICC [2,1] was 0.74 (95%CI: 0.67–0.79; $p < 0.001$), which can be evaluated as good reliability (Koo & Li, 2016).

4. Discussion

We have developed the MBQ, a self-report questionnaire designed to assess an individual's trait level tendency for MB, drawing conceptual inspiration from the MWQ. Initially, development involved formulating the MBQ in Japanese, which was subsequently translated into English. To validate both versions of the MBQ, we employed the same measures for both Japanese and the U. S. participants. We analyzed both datasets using factor and correlational analyses and concluded that the MBQ is a

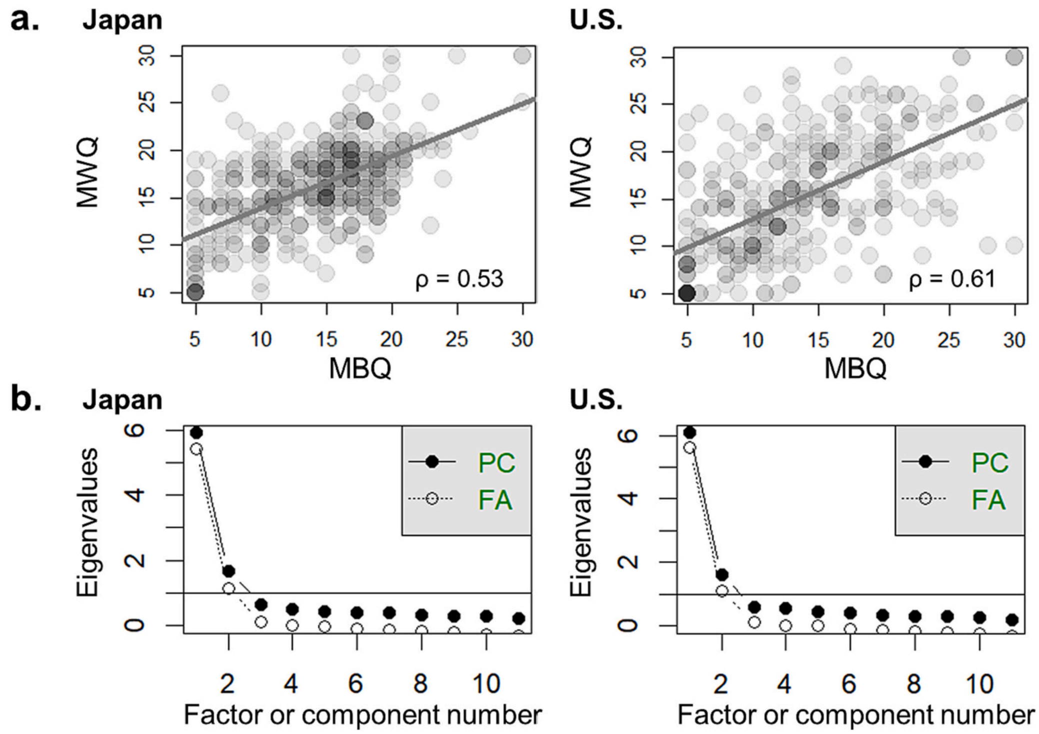

Fig. 3. Plots for the correlation between the Mind Blanking Questionnaire (MBQ) and Mind Wandering Questionnaire (MWQ) (a), and scree plots for the eigenvalues of the ten principal components and factors for the MBQ and MWQ in Japanese and U.S. data (b).
Note: PC = principal component analysis; FA = factor analysis.

Table 4
Results of EFA to confirm the independence of the Mind Blanking Questionnaire (MBQ) and Mind Wandering Questionnaire (MWQ) in Japanese and U.S. data.

	Japan		U.S.	
Item	Factor 1	Factor 2	Factor 1	Factor 2
B-7	**0.97**	−0.13	**0.86**	−0.08
B-4	**0.86**	−0.05	**0.85**	−0.01
B-6	**0.80**	0.06	**0.70**	0.13
B-5	**0.75**	0.03	**0.86**	−0.05
B-3	**0.55**	0.27	**0.68**	0.14
W-2	−0.09	**0.84**	−0.09	**0.84**
W-5	−0.07	**0.83**	0.09	**0.67**
W-1	−0.02	**0.78**	−0.05	**0.90**
W-3	0.10	**0.66**	0.04	**0.77**
W-4	0.11	**0.65**	0.09	**0.65**
Fit index				
RMSR	0.03		0.03	
TLI	0.954		0.940	
RMSEA	0.07		0.09	

Note. Defining factor loadings are in bold. Items starting with B = items in the MBQ; Items starting with W = items in the MWQ; RMSR = root mean square of the residuals; TLI = Tucker Lewis 1ndex; RMSEA = root mean square error of approximation.

valid and reliable single-factor scale to assess trait level MB.

4.1. Cross-cultural, gender and age measurement invariance

First, we established the cross-cultural measurement invariance of the MBQ. Through the stepwise elimination of items in a series of MG-CFAs, we found that the 5-item model possesses strict invariance between languages. Measurement invariance is traditionally required for meaningful and valid comparisons (e.g., between different countries [Byrne et al., 1989; Widaman & Reise, 2004]). The strict invariance that we observed refers to the invariance of the factor loadings, intercepts, and residuals in the structural equation modeling framework which is the strictest form of invariance. Therefore, we consider that the MBQ assesses trait MB tendency equally, at least in Japanese and American respondents. Additionally, we confirmed the invariance of the MBQ in regard to gender and age, suggesting that neither factor systematically biased response patterns.

Nevertheless, one can find slight disparities in the distributional shapes of the items (Fig. 1). The differences cannot be attributed to procedural or translational issues, as most of the items in the U.S. data consistently exhibited a right-skewed distribution, which suggests that the differences observed likely stemmed from cultural influences. This interesting difference might be due to response styles. Previous studies with US/Canadian respondents and Japanese respondents have shown that the former had a higher extreme response style (the tendency to use the extreme response categories on rating scales) while the latter a higher mid-point response style (the tendency to use the middle response categories on rating scales; e.g., Harzing, 2006). Although strict measurement invariance was confirmed and the scores varied adequately, future study is needed to investigate the effect of response style on the MBQ since the experience of MB is difficult to evaluate by oneself, which might magnify the noise resulting from response styles.

In regard to MW, Martinon et al. (2019) reported that while there are only a few studies focusing on cultural differences, nevertheless, the effect of culture was especially significant on the content of MW, even within European respondents (i.e., English and French participants recruited for their study). Obviously, to our knowledge, the effect of culture on MB has not been investigated yet. Although we did not find a difference in scores between the countries, the MBQ provides a means to investigate the effect of culture on consciousness and thought. Similarly, the effects of gender and age on trait MB can be explored using the MBQ.

4.2. Reliability and validity of the mind blanking questionnaire

The 5-item model suggested by the series of analysis for

Table 5
Descriptive statistics for each measure in Japanese and U.S. data.

	Japan (N = 380)				U.S. (N = 321)			
Measures	Mean	SD	Median	IQR	Mean	SD	Median	IQR
MBQ	14.08	5.01	15	10–18	13.71	6.39	13	9–18
MWQ	16.17	4.7	17	14–19	15.13	6.36	15	10–20
Inhibition	31.85	5.23	31	28–35	30.07	4.89	29	27–33
Initiation	33.99	6.19	34	30–38	34.86	6.78	34	30–39
Attention	31.18	6.87	31	27–35	32.22	7.59	32	27–38
ESS	7.85	4.86	8	5–11	7.59	4.57	7	4–10
MAAS	61.43	11.38	60	54–69	58.86	16.97	59	46–71
PHQ-9	6.39	6.26	5	1–9	7.53	6.51	6	2–12

Note. MBQ = Mind Blanking Questionnaire; MWQ = Mind Wandering Questionnaire; Inhibition = Inhibitory control; Initiation = Initiation control; Attention = Attentional control; ESS = Epworth Sleepiness Scale; MAAS = Mindful Attention Awareness Scale; PHQ-9 = Patient Health Questionnaire-9; SD = Standard deviation; IQR = Interquartile range.

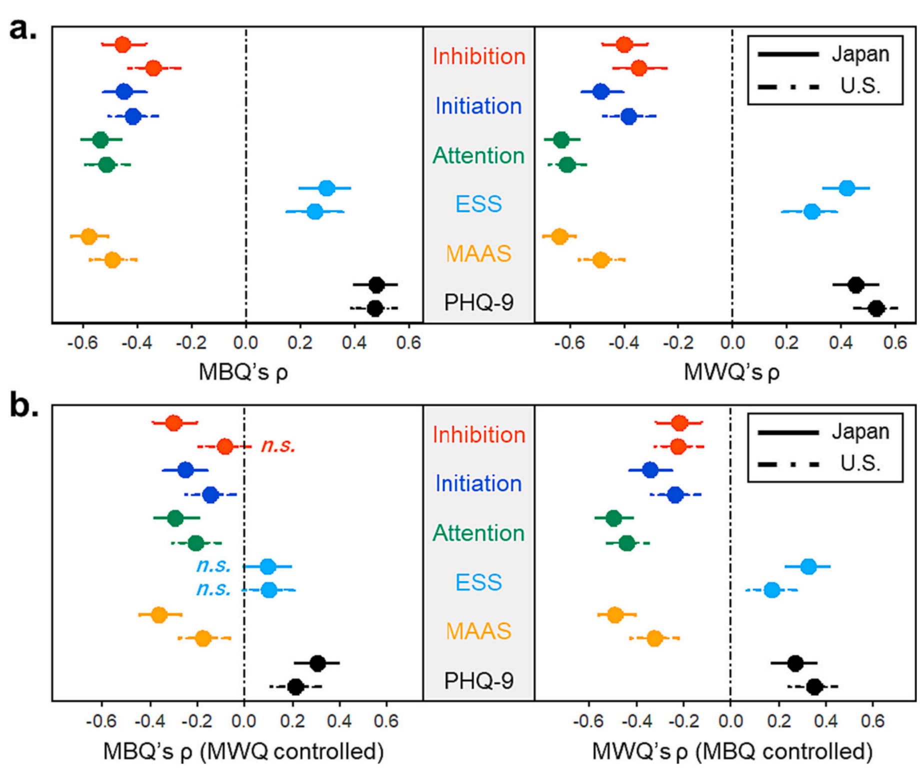

Fig. 4. Simple (a) and partial (b) correlation coefficients showing 95 % confidence intervals for the Mind Blanking (MBQ; left panel) and the Mind Wandering (MWQ; right panel) Questionnaires in data from both languages.
Note: In panel b, the effect of another "mind" questionnaire (i.e., the variable of the MWQ for the MBQ's correlations, and the MBQ for the MWQ's correlations, respectively) was covaried-out in addition to gender and age. All correlations were significant after correction for multiple testing (alpha = 0.05) except those accompanied by n.s. Inhibition = Inhibitory control; Initiation = Initiation control; Attention = Attentional control; ESS = Epworth Sleepiness Scale; MAAS = Mindful Attention Awareness Scale; PHQ-9 = Patient Health Questionnaire-9.

measurement invariance is a single-factor model with good fit as shown in Table 2 (M4_Baseline). Internal consistency (Cronbach's alpha) exceeded 0.90 in both language groups. Furthermore, test-retest reliability was assessed over a two-week interval, indicating a high degree of reliability across time. To further validate the MBQ, we sought to assess its independence from the MWQ, given their apparent similarity. As expected, we observed a significant correlation between scores on these two scales, reflecting their shared elements, such as difficulties in maintaining focus or attention. However, when we conducted an EFA on the pooled dataset, a distinct factor structure emerged, with one factor comprising only items from the MBQ and the other only items from the MWQ. This result underscored the scales' independence, consistent with previous findings at the state level (Ward & Wegner, 2013).

We further explored correlations between MBQ and MWQ scores and scores on the measures employed to validate the MBQ. Simple correlation analyses indicated that the MBQ exhibited the hypothesized associations with other measures: negative correlations with EF and mindfulness measures, and positive correlations with measures of sleepiness and depression. The negative correlation with EF was expected on the basis of the executive failure hypothesis of MW (Kane & McVay, 2012; McVay & Kane, 2010), the core concept of which is that MW occurs as a result of a failure of executive control over internally generated thoughts, and which has been supported not only at the state but also the trait level (Kawagoe, 2022). We confirmed our hypothesis that this was true for MB as well, although the effect size was not so large, as shown in Fig. 4b. A similar explanation can be utilized to explain the negative correlation with the MAAS since a mindful person refers to an individual who can maintain attention and awareness of the ongoing situation (Brown & Ryan, 2003).

Among the associations with measures used for validation, it is most notable that the association between MB and sleepiness was tenuous. Recent neuroscientific studies have reported that MB is similar to sleep, at least at the state level (Mortaheb et al., 2022) and, more specifically, a 'local sleep' might be a neural signature of the MB (Andrillon et al., 2021; Bernardi et al., 2015). Such occurrences of local sleep could represent the neural mechanism underlying many attentional lapses including MW and MB (Andrillon et al., 2019). However, a strong correlation between trait MB and daily sleepiness might have been an issue as it may have arisen from a difficulty in discriminating MB from sleepiness and/or dozing off. Although simple correlation analyses supported their association, partial correlation indicated that the covariance with sleepiness is attributable to the shared factor between MW and MB, and the unique MB component is almost unrelated to the sleepiness at the trait level while MW has a unique covariance with sleepiness. Given the local sleep hypothesis, together with findings that sleep deprivation has reliably induced a type of local sleep akin to microsleep (see Andrillon et al., 2019), one hypothesis for the lessened association between MB and sleepiness found in this study is that people who tend to MB in daily life may be getting rid of neural fatigue. This hypothesis needs to be investigated in future research with a more elaborate methodology.

Finally, we found a positive correlation between trait MB and depression. This is consistent with previous reports (Watts et al., 1988; Watts & Sharrock, 1985), and furthermore, MB was shown to have a unique association with depression which may have important implications for clinical studies regarding the psychological inability to focus and maintain attention and consciousness. As the differences in correlations between the measures and their magnitudes were generally similar in both languages, we concluded that the MBQ was cross-culturally validated between Japan(ese) and U.S.(English).

4.3. Limitations and conclusions

The current study has some limitations which should be noted. Primarily, we did not include a state level or behavioral index of MB. The development process of a psychological scale sometimes includes behavioral testing to investigate the criterion-related validity of the scale. For example, in developing the MWQ, Mrazek et al. (2013) administered a reading comprehension test employing an experience sampling method. However, recent discussion concerning the association between self-report and behavioral measures suggests that these indices assess different aspects of the target psychological construct (e.g., Dang et al., 2020). In actuality, previous studies have shown low degrees of correlation between behaviorally captured MW and scores on the MWQ (Kawagoe et al., 2020; Mrazek et al., 2013; Seli et al., 2016). Thus, we considered the lack of such a measure to be of little importance. Second, a substantial number of participants were excluded because they seemed to adopt satisficing behavior (Krosnick, 1991) especially in US dataset (36 %). This proportion was not unusual however, since previous research has reported that 35 to 46 % of participants exhibited such behavior (Oppenheimer et al., 2009). Third, it is necessary to explore the possibility that the items excluded from consideration (i.e., item 1, 2, and 8) could potentially serve a functional role in shaping the perception or understanding of the remaining items. Another limitation is that the MBQ was validated using only one sample from each country. Further research might be needed to ensure that properties of the measure are similar in other samples from Japan and the U.S.

In summary, we rigorously established the psychometric properties of the 5-item MBQ, demonstrating its validity and reliability, including its distinctiveness from the MWQ, and have identified unique associations with other pertinent measures, in addition to its measurement invariance across different language versions. These findings underscore the utility of the MBQ as a valuable tool for assessing trait MB, a psychological phenomenon that has garnered increased attention in recent years.

CRediT authorship contribution statement

Toshikazu Kawagoe: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **Shinpei Yoshimura:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Seiji Muranaka:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing. **Larry Xethakis:** Methodology, Validation, Writing – review & editing. **Keiichi Onoda:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2023.112539.

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