RESEARCH ARTICLE

Attitudes and habits regarding brain training applications and games among Japanese consumers: a cross-sectional study [version 1; peer review: 2 not approved]

Nigel Robb

University of Tokyo, Tokyo, Japan

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Abstract

Background: While there is now a large amount of research investigating whether brain training applications and games are effective or not, there is less research on the expectations, attitudes, and habits of potential users of brain training programs. Previous research suggests that people generally have positive beliefs about the effectiveness of brain training which are not dependent on their level of experience of brain training. However, this research has primarily focused on western participants.

Methods: In the present study, a questionnaire was used to investigate the attitudes and habits of Japanese consumers towards brain training. The final sample contained responses from 818 people. In addition to descriptive statistics, correlation coefficients were calculated to determine if there were relationships between variables relating to participants' beliefs about brain training and experience of using brain training.

Results: Participants had positive beliefs about the effectiveness of brain training. However, these beliefs were only weakly correlated with their level of experience of using brain training, both in terms of the number programs used (Pearson's $r = 0.163$) and duration of use (Pearson's $r = 0.237$). The most widely used brain training program (used by 52.93% of participants) was made by Nintendo for the handheld Nintendo DS games console.

Conclusions: The research presented here supports previous findings which suggest that people's beliefs about the effectiveness of brain training software are not strongly related to their experience of using such software.

Keywords

brain training, cognitive training, cognitive enhancement

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1. **Yuka Kotozaki** , Iwate Medical University, Morioka, Japan

2. **Kelsey Prena** , Boston University, Boston, USA

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Nigel Robb (nigelrobb@imc.hokudai.ac.jp)

Author roles: Robb N: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing

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Introduction

Recently, there has been much interest in so-called “brain training” (BT) applications and games (the terms “brain training” and “cognitive training” are treated as synonyms in this paper). These programs are typically marketed to consumers as enjoyable, interactive experiences that, if used regularly, are claimed to improve a range of cognitive skills, such as attention, memory, and multitasking ability (Simons *et al.*, 2016). The potential benefits of such training, if effective, are numerous. For example, training executive function skills such as working memory and task switching could potentially lead to improved outcomes in education, quality of life, and employment for the general population (Diamond, 2013). In addition, people with cognitive deficits, such as those with intellectual disabilities or age-related cognitive decline, could also benefit from effective cognitive training software (Robb *et al.*, 2018; Buitenweg *et al.*, 2012).

Research on the effectiveness of various types of cognitive training has found evidence that it can lead to improvements in tasks that bear some resemblance to the training (“near transfer”), but little or no evidence that these improvements transfer to distantly related tasks (“far transfer”) or indeed to everyday life (Simons *et al.*, 2016; Sala *et al.*, 2019; Aksayli *et al.*, 2019). These findings suggest that theories of transfer that emphasize the importance of overlap between the training and the target skills (e.g., Gobet, 2016; Taatgen, 2013; Oei and Patterson, 2014) may provide the best account of the mechanisms by which cognitive training is effective. Therefore, a detailed theoretical understanding of the overlap between the training and the desired outcome may be an important factor in the design of effective, tailored cognitive training programs in the future (see Smid *et al.*, 2020, for this and other recommendations).

As part of a more comprehensive science of cognitive training, it is also important to investigate the attitudes and habits of the people who will potentially use the training. Individual differences in personality, motivation, expectations etc., are likely to play a role in determining a user’s engagement with a training program (Smid *et al.*, 2020). Regular engagement is obviously an important factor in any kind of training; however, attrition is a commonly reported problem in trials of cognitive training software (Corbett *et al.*, 2015; Robb *et al.*, 2019), and at least one commercial BT program (Cogmed) assigns users a coach to ensure that they regularly engage with the software. Understanding how and why people use cognitive training programs may therefore be an important additional factor in determining their effectiveness.

Previous research has found that participants typically have positive beliefs about the effectiveness of BT. Torous *et al.* (2016) found positive beliefs about the effectiveness of BT mobile applications in young American consumers, both in participants who had used BT programs and those who had not. Other research found similar results in parents of children with intellectual disabilities (who may benefit from cognitive training): parents believed that BT could benefit their children and expressed positive attitudes towards supporting such training. Again, these attitudes were not related to how much experience the parents had with BT apps or games (Robb *et al.*, 2018). It has also been shown that people’s expectations about the effectiveness of BT can be influenced by the information they receive about such programs. Rabipour & Davidson (2015) and Rabipour *et al.* (2018) found that participants’ expectations about the effectiveness of BT at baseline could be subsequently raised or lowered by presenting them with positive or negative messages about BT. Finally, Ng *et al.* (2020) found that frequency of engagement was only weakly correlated with perceived cognitive benefit for a range of activities, including BT. However, while this research reveals important information about the attitudes, habits, and expectations of a range of potential consumers of BT, it is primarily focused on Western users. It is widely recognized that much research involving human subjects may be biased towards certain demographics (Henrich *et al.*, 2010). In the case of understanding attitudes and habits regarding BT, the largest previous study was conducted in the United States (Torous *et al.*, 2016). To fully understand the attitudes of BT users, it is vital that a global perspective is considered.

Japan represents a large group of potential consumers of cognitive training who may have different habits or attitudes than, for example, those in the US. Japan also has a developed BT market, with popular BT games having been released in the country for several years (Fuyuno, 2007; Chancellor & Chatterjee, 2011). Therefore, the main purpose of this paper is to understand the habits and attitudes of Japanese people regarding cognitive training, thus expanding our knowledge of how and why such programs are used around the world.

Methods

Questionnaire

To facilitate a direct comparison between Japanese consumers and their American counterparts, this cross-sectional study used a Japanese translation of the questionnaire used by Torous *et al.* (2016) with minor adaptations. Before translation, the original questionnaire was adapted in two ways. Firstly, while Torous *et al.*’s (2016) questionnaire specifically focused on using smartphone apps, the present study also included questions (and adapted the wording of questions) to refer to games consoles. This was because it was expected that Japanese-produced BT programs would be popular among

Japanese people, and [some such software](#) is only available on games consoles. Secondly, when asking participants which cognitive training programs they had used, the list of options was updated to reflect apps and games available in Japan.

This questionnaire was then translated into Japanese by two professional translators, who both independently produced separate translations. Professional translators were contracted through [Gengo](#), a web-based human translation platform. A native Japanese speaker familiar with the research project merged these translations; differences in the two translations were resolved through discussion between this person and the author of the paper. This resulted in a final Japanese version of the questionnaire. Before being used, this version was translated back into English by a third professional translator, and this version was compared with [Torous *et al.*'s \(2016\)](#) original questionnaire. There were some minor differences in the wording of the original questionnaire and the back-translation. For example, “duration” (original) became “period of time” (back-translation); the phrase “For the purpose of this survey, we will call these ‘brain training apps/games’” (original) became “In this survey, we will refer to these as ‘brain training apps/games’” (back-translation); and the question “Do you own a smartphone?” (original) became “Do you have a smartphone?” (back-translation). It was judged that none of these minor differences would affect the meaning of any of the questions. The questionnaire can be viewed in full in both English and Japanese as extended data on the Open Science Framework ([Robb, 2021](#)).

Participants and procedure

Participants were recruited using [CrowdWorks](#), a Japanese crowdsourcing website. All registered CrowdWorks users were deemed eligible to participate; there were no additional inclusion or exclusion criteria. Crowdsourcing websites have been shown to be viable methods for recruiting participants for questionnaire research ([Behrend *et al.*, 2011](#); [Peer *et al.*, 2017](#)). Previously, [Majima *et al.*, \(2017\)](#) compared participants recruited via CrowdWorks with Japanese student samples and found that there were relatively small differences in some personality traits, and that the CrowdWorks participants were (as would be expected) more diverse in terms of age and employment history. The translated questionnaire was uploaded to CrowdWorks and responses collected during December 2017. At the start of the questionnaire, the purpose of the research was explained, and participants were informed that they were not obliged to take part, that their responses would be used for research purposes, and that by continuing with the questionnaire they would be indicating their consent to participate. No identifying information about the participants was collected. All participants were paid 30 JPY (approximately 0.27 USD in December 2017) to complete the questionnaire, whether their response was used in the final analyses or not. The research was conducted according to the recommendations of the Human Research Ethics Committee (Sciences) at University College Dublin, where the lead author of the paper was employed at the time of the research. The protocol was deemed to be exempt from full ethical review as the data were collected anonymously, the participants were not from a vulnerable group, and they were not placed at any risk during the research.

Sample size

Assuming that the number of people aged 16 and over in Japan is approximately 110,000,000 ([Statistics Bureau of Japan, n.d.](#)), and that 50% have used BT (based on results from [Torous *et al.*, 2016](#)), with a margin of error of 5% and a confidence level of 99%, the ideal sample size was calculated to be 664. Given that previous research has highlighted concerns with unreliable responses and high attrition rates in crowdsourced samples ([Keith *et al.*, 2017](#)), 1000 responses were collected.

Statistical analysis

After collection, the data were inspected, and potentially unreliable responses were removed. Unreliable responses included those with inconsistent answers to similar questions, or the wrong answer to the simple sum of nine plus four (included to check that participants were diligently reading and responding to the questions). There were no missing data in the final dataset used for analysis.

Descriptive statistics were used to investigate smartphone and games console ownership of participants; usage of health and fitness apps; concerns about BT; BT apps/games used by participants; and participants' beliefs about the effectiveness of BT. Spearman's correlation coefficients were calculated to determine if there were associations between participants' beliefs about whether BT could lead to cognitive/emotional improvements (specifically in thinking ability, attention, memory, and mood), whether they had used BT, and if they thought BT apps/games had negative side effects. Following [Torous *et al.* \(2016\)](#) a score was calculated for each participant measuring how positively they felt about BT. The difference in this score between participants who had used BT and those who had not was investigated using a Mann-Whitney U-test. Finally, Pearson correlation coefficients were calculated between this score, the number of BT apps/games participants had used, and the longest period of time participants had used BT. These analyses were performed using [JASP](#) version 0.11.1.

Results

A total of 1000 responses were received. Of these, one response was excluded as the age in years was entered as 336, while six responses were removed as they provided an incorrect answer to the sum of nine and four. A further 175 participants' responses were removed as they gave inconsistent answers about their history of using BT apps or games. There were four kinds of inconsistency. Firstly, 13 participants answered "yes" to item 8 ("Have you ever used an app or game that claims to increase memory, concentration, attentiveness, or other cognitive abilities? In this survey, we will refer to these as 'brain training apps/games.'") but answered "I have never used one" to item 16 ("What is the longest period of time you have used a brain training app/game? If you have never used one, please select 'I have never used one.'"). Secondly, 11 participants answered "yes" to item 8 but did not enter any brain training apps or games that they had used when asked to do so in item 15. Thirdly, 111 participants answered "no" to item 8, but indicated they had used BT apps or games in item 16 (i.e., they entered a period of time they had used apps or games). Fourthly, 152 participants answered "no" to item 8, but entered apps or games they had used when asked to do so in item 15. Note that some participants' responses were inconsistent in more than one of these ways. With these responses removed, the final sample used for analyses contained responses from 818 participants (524 female, 294 male; mean age 36.1 years; standard deviation 9.5 years). The underlying data can be accessed on the Open Science Framework (Robb, 2021).

Figure 1 shows the devices and kind of apps owned by participants, divided into four age categories. In all age groups, over 70% of participants owned a smartphone, with the highest rate of smartphone ownership (94.12%) in participants aged 30 years and under. Games console ownership was approximately 40% in the 0-30 years and 31-45 years categories. Almost 45% of participants over 60 years owned a games console, although there were only nine participants in this age group.

The most common concerns participants had about BT apps and games were the cost of the product, the time required to use them, and a lack of certainty regarding their effectiveness. Participants were not generally concerned about the safety of their health data or whether the apps or games have medical recommendation (Figure 2).

The most-used training programs were produced by Nintendo and released on the Nintendo DS handheld games console. Over half the participants reported having used 脳を鍛える大人のDSトレーニング (released in the US as *Brain Age: Train Your Brain in Minutes a Day!* and in Europe as *Dr. Kawashima's Brain Training: How Old Is Your Brain?*) and just under a quarter of participants reported using the follow-up game (もっと脳を鍛える大人のDSトレーニング; US: *Brain Age 2: More Training in Minutes a Day!* Europe: *More Brain Training from Dr. Kawashima: How Old Is Your Brain?*). Of the remaining programs, all but one were used by fewer than 10% of participants. Only 19 participants (2.32%) reported having used *Lumosity* (Figure 3).

Participants indicated positive perceptions of BT apps and games, believing that they could improve thinking ability (79.58%), attention (66.26%), memory (78.61%), and mood (73.35%). Spearman's correlation coefficients were

Figure 1. Percentage of participants with a smartphone and/or games console, and health/fitness apps, divided into four age categories.

Figure 2. Participants' concerns about brain training apps and games.

*Titles are those of the Japanese release of the app or game, e.g., as listed on Google Play or the Apple App Store. In the case that this title is completely in Japanese, the equivalent English-language title(s) of the app or game are provided (e.g., 脳を鍛える大人のDSトレーニング was released in the USA as Brain Age: Train Your Brain in Minutes a Day! and in Europe as Dr. Kawashima's Brain Training: How Old Is Your Brain?).

Figure 3. Brain training apps and games used by participants.

calculated for all combinations of the binary variables (i.e., yes/no questions) regarding participants' views about whether BT could improve thinking ability, attention, memory, and mood, as well as the binary variables regarding whether they had used BT, and if they thought BT had negative side effects. There were weak to moderate positive correlations between (1) thinking ability and attention (Spearman's $\rho = 0.376$, $p < 0.001$), (2) thinking ability and memory (Spearman's $\rho = 0.453$, $p < 0.001$), and (3) attention and memory (Spearman's $\rho = 0.378$, $p < 0.001$) (Table 1).

Following Torous *et al.* (2016), a score was calculated for each participant measuring how positively they felt about BT. Participants were given one point for each positive answer to the four questions about whether they thought BT

Table 1. Spearman correlations between participants' beliefs about whether brain training can improve four mental factors, whether they had used brain training, and whether they thought brain training has negative side effects. All variables are dichotomous yes/no items. Significant at $p = 0.01$ level marked with *.

	Improve thinking ability	Improve attention	Improve memory	Improve mood	Has used brain training apps/games	Apps/games have negative side effects
Improve thinking ability	-	-	-	-	-	-
Improve attention	0.376*	-	-	-	-	-
Improve memory	0.453*	0.378*	-	-	-	-
Improve mood	0.120*	0.143*	0.036	-	-	-
Has used brain training apps/games	0.08	0.096*	0.139*	0.081	-	-
Apps/games have negative side effects	0.085	0.017	0.086	0.008	-0.055	-

Table 2. Pearson correlations between participants' positive beliefs about brain training, the total number of brain training apps or games they had used, and the maximum duration they had used brain training apps or games. Significant at $p = 0.01$ level marked with *.

	Score (positive beliefs about brain training)	Total number of apps/games used	Duration used apps/games
Score (positive beliefs about brain training)	-	-	-
Total number of apps/games used	0.163*	-	-
Duration used apps/games	0.237*	0.479*	-

improved thinking ability, attention, memory, and mood, and one point for a negative answer to the question about whether they thought BT apps and games have negative side effects. The maximum score of five indicated a participant thought BT improved all four factors and had no side effects, while the minimum score of zero indicated a participant thought BT did not improve any of the four factors and had negative side effects. This score was significantly higher among respondents who indicated that they had used BT apps or games (Mann-Whitney U test, $U = 37757$, $p < 0.001$); the rank biserial correlation was -0.213, indicating a weak effect size. This score was weakly positively correlated (Pearson correlation) with both the total number of apps/games a participant had used (Pearson's $r = 0.163$, $p < 0.001$) and the duration they had used BT apps/games (Pearson's $r = 0.237$, $p < 0.001$) (Table 2).

Discussion

The results of the present study suggest that a high rate of Japanese consumers have positive perceptions of the potential benefits of BT apps and games, comparable to or (in the case of positive effects on mood) higher than the rate in US consumers (Torous *et al.*, 2016). While there were correlations between positive perceptions about the effects of BT on specific cognitive factors (thinking ability and attention, thinking ability and memory, and attention and memory), these were weaker than those found in US consumers (Torous *et al.*, 2016). Similarly to Torous *et al.*'s (2016) findings in US consumers, the present study indicates that Japanese consumers are not generally concerned about clinical recommendations, privacy of health data, or negative side effects, when considering BT games. Rather, the cost of apps/games, the time involved, and uncertainty about their effectiveness are the main barriers to BT use in Japan. These results suggest that Japanese consumers and US consumers have broadly similar attitudes and expectations regarding BT apps and games. Previously, it was shown that there were only minor demographic differences (in terms of gender and level of education) in beliefs about benefits of BT (Ng *et al.*, 2020). The present study suggests that, at least in terms of attitudes to BT, variation between people from different socio-cultural backgrounds may also be minor.

The present research revealed large differences in the kinds of BT used by Japanese and US consumers. Perhaps most strikingly, Lumosity, which was used by 70% of US consumers in the previous study by Torous *et al.* (2016) was only used by 2.3% of the Japanese participants. The most popular BT programs were both made by Nintendo and played on the Nintendo DS handheld games console. While the large difference in number of participants using Lumosity may be partly explained by the fact that the app was only released in Japanese in December 2014, these results could also indicate that there are major differences in BT markets in the US and Japan, which would be an important finding. However, since the previous study (Torous *et al.*, 2016) only focused on smartphone apps, it does not provide any information about how widely used Nintendo BT games are in US consumers. Nintendo BT games are popular globally, however: *Brain Age: Train Your Brain in Minutes a Day!* (the most used game among Japanese participants in the present study) was among the 10 best-selling video games of 2006 in the US. It is therefore likely that many of the participants in Torous *et al.*'s (2016) study also had experience of using this BT game.

The results presented here also support previous findings that people's perceptions of the positive effects of BT are not strongly related to their experience of using BT. Torous *et al.* (2016) found that US consumers' positive beliefs about BT were only weakly correlated with the number of BT apps they had used. Similarly, Rabipour *et al.* (2018) found that people with experience of BT had similar expectations about its effectiveness to people with no experience. In other research, Robb *et al.* (2018) found that parents of children with intellectual disabilities had positive beliefs and attitudes regarding BT and had high intentions to support the use of BT by their children, despite the fact that the sample had very little experience with BT programs. Taken together, these results present mounting evidence that experience of using BT is not strongly associated with positive beliefs about the effectiveness of BT. The fact that participants in both the present and previous studies (Rabipour & Davidson, 2015; Torous *et al.*, 2016; Rabipour *et al.*, 2018; Robb *et al.*, 2018) have very positive beliefs about the effectiveness of brain training (whether or not they have actual experience of using BT), combined with the lack of evidence that BT is actually effective (Simons *et al.*, 2016; Sala *et al.*, 2019; Aksayli *et al.*, 2019), illustrates the importance of investigating the role of psychological factors such as motivation, effects of being observed during training and testing, and placebo effects in BT research. It has been shown that users' perceptions about BT can be relatively easily influenced by biased messages regarding their effectiveness (Rabipour and Davidson, 2015; Rabipour *et al.*, 2018), and placebo effects have been found in previous BT research (Boot *et al.*, 2013; Foroughi *et al.*, 2016). Future trials of BT programs would benefit from accounting for such potential confounding factors.

Limitations

To facilitate a direct comparison between Japanese and American users of BT, this study used a direct translation of the questionnaire developed by Torous *et al.* (2016). In this questionnaire, the items referring to participants' positive and negative beliefs about BT (e.g., "Do you think brain training apps and games can improve memory?") were phrased as questions requiring yes/no answers. However, in retrospect, it may have been more informative to adapt the questionnaire to have Likert-style responses. This would still have allowed some comparison with previous research but could have also facilitated more nuanced analysis of the results.

While the use of crowdsourcing platforms such as CrowdWorks to recruit participants is becoming more common in recent research, there remain some potential limitations associated with this approach. Firstly, it is recognized that crowdsourced participants may not always be representative of the population of interest (Stewart *et al.*, 2017). In the present study, this issue is most obvious when considering the ages of the participants: in 2015, 26.6% of the Japanese population were over 65 (Statistics Bureau of Japan, n.d.), whereas in the sample analyzed here, only 9 of 818 participants were over 60. Given that BT is often considered as a potential intervention for people with age-related cognitive decline (Buitenweg *et al.*, 2012), the habits and attitudes of this demographic are clearly important. Secondly, it may be suggested that data collected from crowdsourcing platforms is of low quality (e.g., due to participants answering questions without fully reading or considering them). However, previous research has found data collected via the crowdsourcing platform Amazon Mechanical Turk is of comparable quality to other methods (Kees *et al.*, 2017). In the present study, several indicators were used to identify potentially automated or low effort responses (see section Participants and Procedure). A total of 182 responses (18.2%) were removed before analysis, which is comparable to the rate of 14% automated and low effort responses found in a study of Amazon Mechanical Turk workers by Buchanan & Scofield (2018).

Future work

Due to the low number of participants over 60 years old, the present study cannot provide any reliable information on the attitudes and habits regarding BT in the elderly population in Japan. Future research investigating this topic would be important. Future research could also benefit from using Likert-style items, as discussed in the section Limitations. Further research will also be required to understand more completely the factors that influence people's attitudes towards BT, and the role of psychological confounders such as placebo effects in BT research. Finally, one important finding of the present study is the popularity of BT games produced by Nintendo, emphasizing the importance of games consoles in

the BT market, at least in Japan. Since the previous major study of BT habits in western users only focused on smartphone applications (Torous *et al.*, 2016), future research should investigate if BT programs on games consoles, such those produced by Nintendo, are as widely used in countries other than Japan.

Conclusion

The present study contributes to a growing literature investigating the expectations, attitudes, and habits of potential users of brain training applications and games. There are two main findings. Firstly, similarly to previous research conducted in the US, Japanese consumers have positive beliefs about brain training which do not seem to be strongly associated with the amount of experience they have using such programs. Secondly, the most widely used brain training software among Japanese participants are two games made by Nintendo and played on the handheld Nintendo DS console.

Data availability

Underlying data

Open Science Framework: Attitudes and habits regarding brain training games and apps in Japan, <https://doi.org/10.17605/OSF.IO/CW5AG> (Robb, 2021)

This project contains the following underlying data:

- raw-data-retrieved-4-24-2020.csv (File exported from CrowdWorks)
- raw-data-jp (Spreadsheet of questionnaire responses in Japanese)
- raw-data-en (Spreadsheet of questionnaire responses in English)

Extended data

Open Science Framework: Attitudes and habits regarding brain training games and apps in Japan, <https://doi.org/10.17605/OSF.IO/CW5AG> (Robb, 2021)

This project contains the following extended data:

- questionnaire-v3-final_jp.pdf (Questionnaire in Japanese)
- questionnaire-v3_en-back-translation.docx (Questionnaire back-translated to English)

Data are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

Competing interests

No competing interests were disclosed.

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Kelsey Prena

Emerging Media Studies, College of Communication, Boston University, Boston, MA, USA

The article summarizes 818 participants' opinions about brain training games, arguing a Japanese sample makes the paper unique. I compliment the comprehensive review of current research in the beginning of the paper and detailed but clear and concise results section. My comments are listed below.

Major comments:

1. The author gives no theoretical support for why they chose Japan (though it does look like grant money may have been involved). A sound theoretical foundation would have provided a framework for anticipating differences across cultures (as the author tries to make claims about in the discussion section). Lack of this foundation, and lack of hypotheses in consideration of this framework, indicates that this study is going to primarily summarize the market rather than make greater contributions to the discipline's landscape. Furthermore, without this theoretical support, the paper's method, results, and discussion become more of a free-for-all for the author to pick and choose. Other concerns related to this major comment include:

- Why did the author select the particular age groups listed in Figure 1? They seem extraordinarily broad and hide important detail from the reader.

2. The author indicates that it can be concluded that Japanese consumers aren't concerned about clinical recommendations, privacy of health, or negative side effects when considering brain training games. I do not think they can draw this conclusion based on the method. This was not analyzed in the results section, or discussed in the method section, and the conclusion feels very random. I have reviewed the survey items, and do not believe this can actually be concluded based on the questions provided. Lack of answer does not equate to lack of concern. Similar arguments can be made for other conclusions listed here:

- The author includes the following comment in the conclusion: *"the present study suggests that, at least in terms of attitudes to BT, variation between people from different socio-cultural*

backgrounds may also be minor." This cannot be concluded by the current method. There were no questions asked or analyzed to draw this conclusion.

-The author indicates major differences between the Western and Japanese BT markets as a core conclusion to the article. However, they later consider in the discussion that these differences might be because of differences in software availability. I'm not sure that this conclusion really contributes to the paper, and I don't believe it can be concluded accurately without further research.

3. The author uses single-item variables for all measures, most of them with answer options of simply "yes" or "no." I know this is in replication of a heavily cited other study (Torous *et al.*, 2016¹), but there are many problems with this methodology and question the integrity of the validity of the measure. The author, appropriately, includes this as a limitation but it's a major one. I have a hard time trusting that these questions get at the true answers, and yields this study's conclusions as preliminary rather than substantial.

Minor comments:

1. Is brain training actually synonymous with cognitive training? In some cases it can be, but the author makes this claim and then presents a slightly different definition of brain training in the third paragraph.
2. It's my understanding that Spearman's Rho should only be used with rank-order variables, and we have dichotomous variables here, not rank-order variables.

References

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Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Communication neuroscience, video games, learning, memory

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 14 Sep 2021

Nigel Robb, University of Tokyo, Tokyo, Japan

Thank you for your review. My apologies for the delay in my response. I've updated the manuscript now to address your comments. I've made the following changes:

Major comments

1. I've added more detail to the introduction about the justification for using a Japanese sample. Specifically, I have shown that there is evidence from previous research that, when it comes to mobile app use behaviors and attitudes, it is reasonable to anticipate differences between users from Japan and from the US. So, since the previous study focused on American users and Japan is a highly-developed brain training market, I think it is justified to study Japanese consumers. To clarify, the funding from the Japanese funder (Kaken grant) was awarded *after* the data collection in the present study was completed, so grant money in no way influenced the decision to choose Japan.

- I have changed the age groups in Figure 1, now using seven categories.

2. I've reworded the interpretation of the results to soften my claims about Japanese consumers' concerns regarding BT.

- I have reworded the interpretation of the results regarding socio-cultural differences and changed the language to emphasize that this is a preliminary study with limited findings
- I have removed the claim that there are major differences between the Japanese and US BT markets and instead just pointed out the differences between this and the previous study in this respect.

3. I agree this is the major limitation of the study, and I've made that more explicit in the limitations section. I have also changed the language throughout the paper to emphasize that these results are preliminary and that hypothesis-testing in future research would be required.

Minor comments

1. I removed the point about BT being synonymous with cognitive training.

2. In this case, Spearman's Rho, Pearson's r , and the phi-coefficient are all equivalent. However, I agree that it would be better to report the statistic in a way that is more recognized as appropriate for binary variables, so I have changed these results to report the

phi-coefficient (although the values remain the same).

Again, thank you for your help in improving the manuscript. Your feedback is greatly appreciated.

Competing Interests: No competing interests were disclosed.

Reviewer Report 05 February 2021

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Yuka Kotozaki

Iwate Medical University, Morioka, Japan

- You are using the Japanese translation of the questionnaire used by Torous et al. (2016). Before conducting this survey, did you verify that the results obtained from the Japanese translated version of the questionnaire are equivalent to the original questionnaire?
- In the case of a manuscript, even if the product name is in Japanese, I think it would be better to describe it in English (or in romaji, etc.).
- As for the correlation, if it is around 0.2, it is almost uncorrelated rather than weakly correlated, isn't it? Generally speaking, 0 to less than 0.3: almost no correlation, 0.3 to less than 0.5: very weak correlation, 0.5 to less than 0.7: correlation, 0.7 to less than 0.9: strong correlation, and 0.9 or more: very strong correlation.
- Should the impact of gender differences not be considered? If the difference between men and women was not examined because there was no significant difference, I think an explanation to that effect and presentation of the results would be necessary.

I think it is an interesting study, but I think it needs to be carefully examined again for more detailed results and correlations.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 14 Sep 2021

Nigel Robb, University of Tokyo, Tokyo, Japan

Thank you very much for taking the time to review the article, and I apologize for taking so long to respond to your comments. I've updated the manuscript now to address your concerns as follows:

1. Apart from the rigorous translation/back-translation process, there were no further checks to verify that the results obtained are equivalent to the original English questionnaire. Given that (1) the questionnaire does not really have multiple items measuring the same construct and (2) it is possible that there are differences between Japanese and American respondents, it may not be feasible to do this kind of verification. I have added some text to the limitations to make this clear.
2. I've changed all the product names to either romaji or English.
3. I have altered the interpretation of the correlation coefficients slightly and added citations to justify the interpretations used here. I agree that several of the correlations found here are negligible, so I have used this word to clarify that. I do think that it is reasonable in this context to interpret a correlation of >0.4 as weak to moderate (Akoglu, 2018).
4. I analysed the impact of gender differences and added these results into the manuscript.

Thank you again for your helpful comments, I really appreciate the feedback.

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Competing Interests: No competing interests were disclosed.

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