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

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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
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 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.
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
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 improved thinking ability, attention, and memory. 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).
 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).

### 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 *.

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

### 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 *.

<table>
<thead>
<tr>
<th></th>
<th>Score (positive beliefs about brain training)</th>
<th>Total number of apps/games used</th>
<th>Duration used apps/games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score (positive beliefs about brain training)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total number of apps/games used</td>
<td>0.163*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Duration used apps/games</td>
<td>0.237*</td>
<td>0.479*</td>
<td>-</td>
</tr>
</tbody>
</table>

### 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.

Acknowledgements
Tomonori Hasegawa assisted with the translation of the questionnaire into Japanese.

References


Robb N: Attitudes and habits regarding brain training games and apps in Japan [Data set]. Publisher Full Text


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

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.

Reviewer Report 05 February 2021

https://doi.org/10.5256/f1000research.45191.r77997

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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.

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