Moral foundations and cognitive ability: Results from a Japanese sample

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ABSTRACT

Research has indicated that human morality is associated with cognitive ability. However, morality is not a unified concept but rather is a multi-faceted concept. Moral Foundation Theory suggests that human beings have at least five innate moral foundations: Care/Injury, Fairness/Deception, Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen. The present study aimed to investigate the associations between these moral values and cognitive ability. A large-scale cross-sectional survey was conducted online, which was completed by a total of 4863 Japanese adults (2922 females, 1935 males, and 6 "other;" M_{age} = 48.78, SD_{age} = 10.93, range 20–70). Correlation and multiple regression analyses revealed that cognitive ability was positively linked to Care/Injury, Fairness/Deception, and Sacred/Fallen. Notably, the positive associations of cognitive ability with Loyalty/Betrayal and Authority/Subversion were statistically significant only for people below the age of approximately 50. These findings indicate that although moral foundations are based on emotions and intuitions, they are substantially associated with cognitive ability. In addition, the positive direction of associations of cognitive ability with Loyalty/Betrayal and Authority/Subversion was inconsistent with previous findings in Western countries, which suggests that these associations are culture-dependent.

1. Introduction

Human beings are social animals; we go about our everyday lives establishing social relationships. This renders it necessary for us to behave morally in society (de Waal, 1996). There are broad individual differences in moral behaviors, which can be well explained by variability in moral values. Moral Foundations Theory (MFT) suggests that we inherently have five broad intuitive moral foundations (Graham et al., 2011, 2013; Graham, Haidt, & Nosek, 2009). The five moral foundations are as follows: Care/Injury, Fairness/Deception, Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen.

Care/Injury is represented by virtues of warm-heartedness, humaneness, and nurturance. Fairness/Deception refers to ideas of justice, rights, and impartiality. Care/Injury and Fairness/Deception are called *individualizing* foundations, which include all that are needed to support the individual-focused contractual approaches to society often used in enlightenment ethics and are highly associated with liberal ethics (Graham et al., 2009, 2011). Loyalty/Betrayal reflects trueness, patriotism, and self-abnegation for one's group members. Authority/Subversion represents deference to legitimate power, authority, and respect

for traditions. Sacred/Fallen denotes the abhorrence of disgusting things and contamination. The latter three foundations are referred to as *binding* foundations, which are linked to all that binds people together into larger groups and institutions (Graham et al., 2009, 2011).

These foundations are innate and are related to moral-related emotions; MFT holds that human beings usually rely on their moral intuitions based on the five foundations in determining moral judgements (Graham et al., 2009, 2011). Although these foundations are intuitive and are related to emotion, recent research has investigated and shown the associations between the main moral foundations and cognitive ability. For example, a previous study using a young adult sample showed that cognitive ability is negatively associated with *binding* foundations (Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen) but not with *individualizing* foundations (Care/Injury and Fairness/Deception) (Pennycook, Cheyne, Barr, Koehler, & Fugelsang, 2014). Regardless of the exact nature of the associations between cognitive ability and moral foundations, some previous research studies have presented consistent findings. According to Graham et al. (2009), although both liberals and conservatives similarly placed much value on Care/Injury and Fairness/Deception (*individualizing*

foundations), only conservatives regarded Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen (*binding* foundations) as important. That is, liberals and conservatives differentially display their moral foundation responses (Graham et al., 2009, 2011). Some previous research with student samples has shown that cognitive ability is negatively associated with conservative values (Stankov, 2009) and that lower educational attainment is also linked to stronger political conservatism (Sidanius, Pratto, & Bobo, 1996). By contrast, another line of research has shown that higher cognitive ability and higher educational attainment are cross-sectionally and longitudinally associated with more liberal social attitudes (Carl, 2014, 2015; Deary, Batty, & Gale, 2008; Schoon, Cheng, Gale, Batty, & Deary, 2010). To wrap up, these previous findings indicate that higher cognitive ability is related to higher *individualizing* and lower *binding* foundations.

However, some inconsistent findings have been reported on these associations. For example, an experimental study provided results suggesting that *binding* foundations among conservatives are "cognitively enhanced" (Wright & Baril, 2011). In addition, using a very large sample ($N > 86,000$), Van Leeuwen and colleagues showed that high educational attainment was positively associated with *individualizing* foundations, but its associations with *binding* foundations were inconsistent and mixed (Van Leeuwen, Koenig, Graham, & Park, 2014). The findings of their multilevel analyses showed that higher educational attainment was associated with stronger identification with *individualizing* moral foundations and two of the three *binding* moral foundations (Authority/Subversion and Sacred/Fallen). Similarly, Kemmelmeier (2008) provided inconsistent findings for an association between cognitive ability and conservative ideology. His findings indicated that political involvement might moderate this association; lower cognitive ability was linked to higher conservatism in states with high political involvement but was associated with lower conservatism in states with low political involvement. Kemmelmeier (2007) also showed that personal involvement in the political domain moderates the link between personality and conservatism ideology.

Research on public opinion has suggested that political interest and engagement moderate the association between values and attitudes toward social issues (Kemmelmeier, Burnstein, & Peng, 1999; Krosnick, 1988, 1990). Specifically, compared to those who have little political interest, individuals who have high political interest are more likely to consider political affairs and explain political issues in their daily lives more frequently. This cognitive elaboration renders them cautious in applying their values to social issues and in furthering consistency between values and beliefs. By contrast, those with little political interest tend to have fewer opportunities than their highly politically interested counterparts to think about and discuss political issues. This tendency lends itself to high consistency between one's values and beliefs. Based on these findings, the negative associations between cognitive ability and *binding* moral foundations may not generalize well to the overall population.

To the best of our knowledge, previous findings were obtained from Western samples. According to national statistics, Japanese people show relatively lower political behaviors than Westerners. In particular, the proportion of Japanese youth who are reluctant to participate in decision-making regarding social affairs is much higher than that of other countries (Cabinet Office, 2014). In addition, although the average of voting rate was 67% across the OECD countries, that in Japan is on the low side with approximately 50% (OECD, 2016). Moreover, confidence in national government of Japanese people is also lower than the OECD average (OECD, 2016). In short, the political engagement of the Japanese public, especially among young people, is lower than many other countries. Hence, based on the findings reported by Kemmelmeier (2007, 2008), the associations of cognitive ability with moral foundations are expected to differ from those of Western countries. Given that higher cognitive ability has been consistently linked to stronger identification with *individualizing* moral foundations (Carl, 2014, 2015; Deary et al., 2008; Schoon et al., 2010; Van Leeuwen

et al., 2014), we would expect that the same would hold true for Japanese people. However, as for the associations with *binding* foundations, since Japanese people have lower political interest than Western ones, positive associations may emerge between cognitive ability and *binding* foundations. In addition, since young people in Japan tend to be socially and politically withdrawal (Cabinet Office, 2014), we can expect interaction effects of age, that is, positive associations are likely to be stronger for younger people than older ones.

2. Materials and methods

2.1. Participants and procedures

The present study involved conducting a web-based cross-sectional survey. The survey was conducted with a research panel provided by Cross Marketing Inc. (http://global.cross-m.co.jp/index.html). This survey was approved by the institutional review boards of Waseda University and Kwansei Gakuin University as part of the project "Data-Sharing for Psychology in Japan (DSPJ)." The panel participants were Japanese residents who provided informed consent online to participate. Panel registrants aged 20–70 received e-mail invitations about participation in this study in January 2017. A total of 4863 Japanese adults (2922 women, 1935 men, and 6 "other") completed the survey without any missing data. This sample size of 4863 participants enabled > 99% power to detect zero-order effects as small as $r = 0.06$. The mean age of the participants was 48.78 years ($SD = 10.93$, range 20–70, *Median* = 49).

2.2. Measures

2.2.1. Moral foundations

The Japanese version of the 30-item Moral Foundations Questionnaire (MFQ; Graham et al., 2011) was utilized to measure moral foundations. The MFQ measures five domains of moral foundations, namely Care/Injury ($\alpha = 0.80$), Fairness/Deception ($\alpha = 0.74$), Loyalty/Betrayal ($\alpha = 0.66$), Authority/Subversion ($\alpha = 0.66$), and Sacred/Fallen ($\alpha = 0.71$). It contains two sections. The first section taps into people's evaluations of the moral relevance of several moral considerations on a six-point Likert scale ranging from not at all relevant (0) to extremely relevant (5). The second section measures the degree to which participants agree or disagree with moral judgment statements using a six-point Likert scale ranging from strongly disagree (0) to strongly agree (5). Items were summed and averaged to create a score for each moral foundation domain and higher-order moral dimensions.

2.2.2. Cognitive ability

Cognitive ability was measured with the BAROCO Short (Shikishima et al., 2011). The BAROCO Short is the self-administered syllogism-solving test consisting of five problems. Syllogism is a kind of argument which involves applying deductive reasoning to arrive at a conclusion by thinking of two premises. Previous research indicated that ability for syllogistic logical deductive reasoning highly reflects general intelligence (Shikishima et al., 2009). In addition, it was shown that the BAROCO Short can be used to easily measure general cognitive ability (Shikishima et al., 2011). Internal reliability was calculated based on the tetrachoric correlations among the five items. The reliability was adequate ($\alpha = 0.72$) and was nearly the same with the previous results (Shikishima et al., 2011). The total score on the five problems, which ranges from 0 (all incorrect) to 5 points (all correct), was used in the analysis.

2.2.3. Confounding variables

In order to control for some confounding variables, the present study measured participants' age, gender (0 = women; 1 = men; 2 = "other"), educational attainment level (0 = graduated high school or less, 1 = some college or technical school, 2 = graduated from

college or some graduate work, 3 = obtained a post-graduate degree), household annual income (0 = up to 3,000,000 JPY, 1 = 3,000,000–5,999,999 JPY, 2 = 6,000,000–8,999,999 JPY, 3 = 9,000,000 JPY or greater), and the Big Five personality traits. The Big Five is a well-established measurement model for measuring human personality with five broad domains: extraversion, agreeableness, conscientiousness, neuroticism, and openness (John, Naumann, & Soto, 2008). Research has indicated that the Big Five personality domains are slightly associated with the main moral foundations (Hirsh, DeYoung, Xu, & Peterson, 2010; Lewis & Bates, 2011; but see Kawamoto, Van der Linden, & Dunkel, 2017) and cognitive ability (Furnham, Dissou, Sloan, & Chamorro-Premuzic, 2007; Rammstedt, Danner, & Martin, 2016).

The Big Five personality traits were measured using the Japanese version of the Ten Item Personality Inventory (TIPI-J: Oshio, Abe, & Cutrone, 2012). The TIPI-J measures the five dimensions of personality. Each domain is measured with two items rated on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The within-scale correlation coefficients between the positively and negatively keyed items on each scale were − 0.42 (95%CI = [−0.44, −0.39]), −0.20 (95%CI = [−0.23, −0.17]), −0.35 (95%CI = [−0.37, −0.32]), −0.28 (95%CI = [−0.31, −0.25]), and −0.26 (95%CI = [−0.28, −0.23]) for extraversion, agreeableness, conscientiousness, neuroticism, and openness, respectively, which are comparable with those found in a previous study of Japanese people (Oshio et al., 2012).

2.3. Statistical analysis

In order to investigate the associations between the different moral foundations and cognitive ability, we conducted multiple regression analyses for each moral foundation, and the BAROCO Short score was converted to a z score (*Mean* = 0, *SD* = 1) using the sample mean and sample standard deviation. We set each moral foundation scale score as a dependent variable and dealt with the BAROCO Short score as an independent variable. As the present study also aimed at examining the potential moderation effect of age on the association between moral values and cognitive ability, we included an age-by-cognitive ability interaction term into the analyses. All statistical analyses were performed with R 3.4.1.

3. Results

3.1. Descriptive statistics and correlation analyses

Table 1 presents the descriptive statistics for the moral foundations and cognitive ability. No strongly biased distributions were observed. We computed all correlation coefficients between moral foundations and cognitive ability. The detailed correlations are reported in Table 1. All correlations were statistically significant, and the associations of cognitive ability with Care/Injury, Fairness/Deception and Sacred/Fallen were substantial (rs > 0.14). By contrast, Loyalty/Betrayal and

Authority/Subversion were very weakly correlated with cognitive ability in a positive direction. The descriptive statistics of confounding variables are given in supplemental Table S1.

3.2. Associations between the moral foundations and cognitive ability

In order to control for age, gender, educational attainment level, household annual income, and the Big Five personality traits, we conducted multiple regression analyses. Additionally, since the present study aimed to investigate the moderating effect of age on the associations between moral values and cognitive ability, we entered the interaction terms of age and cognitive ability into the regression models. Supplemental Table S2–S6 present the regression coefficients for cognitive ability on each moral foundation. The results revealed that cognitive ability was positively and significantly associated with all moral foundations except for Authority/Subversion (B = 0.179, 95%CI = [0.153, 0.206] for Care/Injury; B = 0.149, 95%CI = [0.121, 0.176] for Fairness/Deception; B = 0.031, 95%CI = [0.003, 0.059] for Loyalty/Betrayal; B = 0.126, 95%CI = [0.099, 0.154] for Sacred/Fallen) after controlling for the participants' age, gender, educational attainment level, household annual income, and the Big Five personality traits.

The interaction term between age and cognitive ability was significantly related to all moral foundations (B = −0.003, 95%CI = [−0.005, −0.000] for Care/Injury; B = −0.003, 95%CI = [−0.005, −0.000] for Fairness/Deception; B = −0.003, 95%CI = [−0.005, −0.000] for Loyalty/Betrayal; B = −0.003, 95%CI = [−0.006, −0.001] for Authority/Subversion; B = −0.003, 95%CI = [−0.006, −0.001] for Sacred/Fallen). This implies that the associations of cognitive ability with moral foundations were moderated by the participants' age. To further explore this, we conducted simple slope analyses. The detailed results are presented in Table 2. With respect to Care/Injury, Fairness/Deception and Sacred/Fallen, the associations with cognitive ability were positive and statistically significant for every age (25, 35, 45, 55, and 65 years). However, the associations with Loyalty/Betrayal and Authority/Subversion were significant only for younger ages.

Then, in order to show the values of age for which the simple slope was statistically significant, we also conducted the Johnson–Neyman test for establishing regions of significance. The results indicated that higher cognitive ability was significantly associated with higher levels of Care/Injury, Fairness/Deception, and Sacred/Fallen in the observed age range (20–70 years). As for Loyalty/Betrayal, higher cognitive ability was significantly linked to higher level of Loyalty/Betrayal in individuals whose ages were < 49.71 years. With respect to Authority/Subversion, higher cognitive ability was also significantly linked to higher level of Authority/Subversion in individuals whose ages were < 47.91 years. The confidence bands for Loyalty/Betrayal and Authority/Subversion are shown in Fig. 1.

Table 1
Descriptive statistics and correlation coefficients between moral foundations and cognitive ability.

Variables	Mean	SD	Correlation coefficients				
			1	2	3	4	5
Moral foundations							
1 Care/Injury	3.151	0.852					
2 Fairness/Deception	2.858	0.745	0.835 [0.826, 0.843]				
3 Loyalty/Betrayal	2.506	0.665	0.571 [0.552, 0.590]	0.618 [0.601, 0.635]			
4 Authority/Subversion	2.457	0.668	0.482 [0.460, 0.503]	0.522 [0.501, 0.542]	0.772 [0.761, 0.783]		
5 Sacred/Fallen	2.763	0.727	0.734 [0.721, 0.747]	0.722 [0.708, 0.735]	0.680 [0.664, 0.694]	0.672 [0.656, 0.687]	
Cognitive ability							
6 BAROCO short	2.138	1.508	0.206 [0.179, 0.233]	0.169 [0.141, 0.196]	0.041 [0.013, 0.069]	0.034 [0.006, 0.062]	0.144 [0.117, 0.172]

Notes. 95%CIs for correlation coefficients are presented in parentheses. 95%CIs not inclusive of zeroes indicate statistically significant correlations.

Table 2
Results of simple slope analyses.

Dependent variables	Moderator (Age)	B	B SE	95%CI	p
Care/Injury	25 years	0.247	0.032	[0.184, 0.310]	< 0.001
	35 years	0.219	0.022	[0.176, 0.261]	< 0.001
	45 years	0.190	0.014	[0.162, 0.218]	< 0.001
	55 years	0.161	0.016	[0.131, 0.192]	< 0.001
	65 years	0.133	0.024	[0.086, 0.180]	< 0.001
Fairness/Deception	25 years	0.211	0.033	[0.146, 0.276]	< 0.001
	35 years	0.185	0.022	[0.141, 0.229]	< 0.001
	45 years	0.159	0.015	[0.130, 0.188]	< 0.001
	55 years	0.132	0.016	[0.101, 0.164]	< 0.001
	65 years	0.106	0.025	[0.058, 0.154]	< 0.001
Loyalty/Betrayal	25 years	0.098	0.034	[0.031, 0.165]	0.004
	35 years	0.070	0.023	[0.025, 0.115]	0.002
	45 years	0.042	0.015	[0.012, 0.072]	0.006
	55 years	0.013	0.016	[−0.019, 0.046]	0.415
	65 years	−0.015	0.025	[−0.065, 0.035]	0.558
Authority/Subversion	25 years	0.103	0.034	[0.035, 0.170]	0.003
	35 years	0.070	0.023	[0.025, 0.116]	0.002
	45 years	0.038	0.015	[0.008, 0.068]	0.014
	55 years	0.006	0.017	[−0.027, 0.038]	0.733
	65 years	−0.027	0.026	[−0.077, 0.023]	0.296
Sacred/Fallen	25 years	0.203	0.034	[0.138, 0.269]	< 0.001
	35 years	0.171	0.023	[0.127, 0.215]	< 0.001
	45 years	0.139	0.015	[0.109, 0.168]	< 0.001
	55 years	0.106	0.016	[0.075, 0.138]	< 0.001
	65 years	0.074	0.025	[0.025, 0.123]	0.003

4. Discussion

The present study examined the associations between moral foundations and cognitive ability and the moderating effect of age on these associations using a large Japanese adult sample. Cognitive ability was positively associated with *individualizing* foundations (Care/Injury and Fairness/Deception) in this study. This result is basically consistent with previous findings (Carl, 2014, 2015; Deary et al., 2008; Schoon et al., 2010; Van Leeuwen et al., 2014). In addition, cognitive ability was also positively correlated with *binding* foundations (Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen). These associations were inconsistent with previous Western findings (Pennycook et al., 2014; Sidanius et al., 1996; Stankov, 2009). However, as Kemmelmeier (2008) noted, the associations between cognitive ability and conservatism-related values might be moderated by environmental political interest. Since Japanese people, especially young ones, have among the lowest political interest and engagement rates (Cabinet Office, 2014), the positive associations of cognitive ability with *binding* foundations were expected. Hence, the present hypotheses on the moral-cognitive ability associations were supported by this study. As for age as a moderator, interaction terms were significant for all moral foundations. A subsequent simple slope test showed that the links to each moral foundation were stronger for younger people. Moreover, the Johnson–Neyman test revealed that the moral-cognitive ability links became significant among people below the age of approximately 50 for *binding* foundations other than Sacred/Fallen. Therefore, the present age-as-moderator hypothesis was partially supported in this study.

Five moral foundations are considered as innate psychological
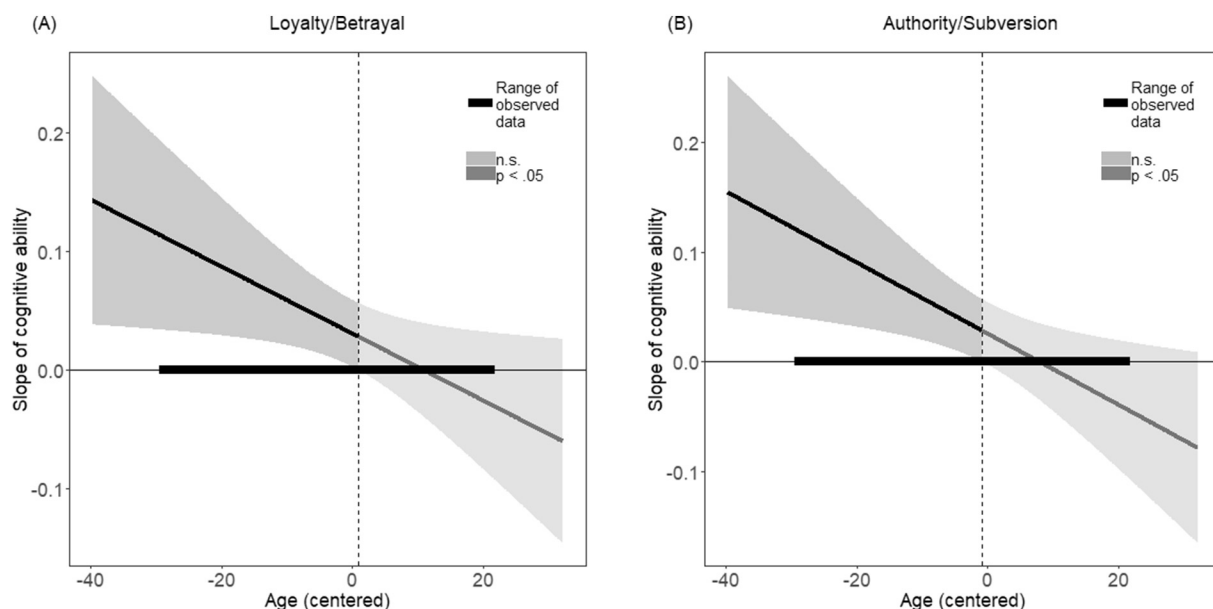
Fig. 1. Confidence bands for the interaction between age and cognitive ability predicting (A) Loyalty/Betrayal and (B) Authority/Subversion.
Note. Age was centered by its entire mean (48.78 years).

systems that give rise to moral intuitions throughout the world (Graham et al., 2009, 2011, 2013). According to the MFT, the five intuitive systems are respectively linked to distinct moral values: Care/Injury, Fairness/Deception, Loyalty/Betrayal, Authority/Subversion, and Sacred/Fallen (Graham et al., 2009, 2011, 2013). The MFT focuses on the role of emotional intutions in determining moral judgment and insists that moral judgements derive almost entirely from intuitive processes (Graham et al., 2013). That is, although they do not deny the role of cognitive reasoning processes (Graham et al., 2011), deliberate cognitive reasoning is not overly assumed in MFT. The present results showed that higher cognitive ability is linked to higher levels of every moral foundation, especially Care/Injury, Fairness/Deception, and Sacred/Fallen. While the present results basically conformed to previous findings (Carl, 2014, 2015; Deary et al., 2008; Schoon et al., 2010; Van Leeuwen et al., 2014), the underlying reason why these foundations are positively related to cognitive ability remains unknown. Moreover, the present study showed that age exerted a moderating effect on the associations between cognitive ability and moral foundations. In particular, with respect to Loyalty/Betrayal and Authority/Subversion, the associations with cognitive ability were observed only in younger people. Considering that Japanese young people show low political interest and engagement (Cabinet Office, 2014), this age-by-cognitive ability interaction is consistent with previous research findings (Kemmelmeier, 2008; Kemmelmeier et al., 1999; Krosnick, 1988, 1990).

The associations between cognitive ability and moral foundations observed in this study can be interpreted from the viewpoint of social learning or enculturation. According to MFT, moral foundations are basically innate (Graham et al., 2011, 2013). However, they also note that these foundations are malleable, and there is room for cultural learning (Graham et al., 2013). Cognitive ability is a fundamental tool for human learning, and is also a useful tool for social learning (Christie, 2017). Although there are some differences in the moral values regarded as important among various cultures or societies, care and justice are seen as basic morality in at least developed countries. Children socially learn their importance as moral principles and become socialized (Smetana, 1999). Cognitive ability plays an important role in this social learning process, which promotes positive associations with Care/Injury and Fairness/Deception, that is, *individualizing* foundations.

Sacred/Fallen is considered as one of the *binding* foundations (Graham et al., 2009). However, the present results on Sacred/Fallen were not consistent with Loyalty/Betrayal and Authority/Subversion, but rather similar with Care/Injury and Fairness/Deception. Considering the raw inter-scale correlations among moral foundations, Sacred/Fallen can be construed as more closely associated with *individualizing* foundations in Japanese people. Previous research also showed that openness to experience and honesty-humility are positively associated with Care/Injury, Fairness/Deception and Sacred/Fallen in Japanese (Kawamoto et al., 2017). Based on these findings, the location of Sacred/Fallen in moral foundation factor structure for Japanese people may be different from that for Westerners.

The present results pointing to age as a moderator of the associations between cognitive ability and moral foundations are novel. In particular, the associations with Loyalty/Betrayal and Authority/Subversion were observed only for people below the age of 50. Loyalty/Betrayal and Authority/Subversion are linked to social conservatism (Graham et al., 2009, 2011). People with little political interest tend to have less opportunities to think about and discuss political issues; this tendency is conducive to maintaining high consistency between values and beliefs (Kemmelmeier et al., 1999; Krosnick, 1988, 1990). Besides, Japanese young people have little political interest and engagement (Cabinet Office, 2014). Considering these previous findings, Japanese young people may passively accept conservative values that are widely endorsed in the Japanese society without questioning them, since their surroundings are characterized by low political interest. This holds especially true for young individuals with relatively high cognitive ability, since the processes involved in learning social values or norms necessitate high cognitive ability (Buckholtz & Marois, 2012; Christie, 2017). Therefore, it is plausible to argue that younger and smarter people are more likely to passively accept conservative values, which are widely endorsed in Japan, without analyzing them.

The present study had some strengths including a sufficient sample size and the use of a Japanese sample. As research on moral foundations has been mainly conducted in Western countries, the present results extended previous findings. Despite these strengths, this study also had some limitations. First, we relied on self-reported moral foundation scores; mono-rater measures of psychological traits are vulnerable to random and systematic errors (Campbell & Fiske, 1959). Future research ought to use other self-rating measures or other methods to assess people's morality. Second, the present sample was composed only of Japanese individuals. Accordingly, future research should recruit culturally and ethnically diverse samples. Third, cognitive ability was measured with the BAROCO Short, which has been well validated but is a relatively simple test. In order to further examine the associations between moral foundations and detailed facets of cognitive ability, future research should use tests that can capture the multiple facets of cognitive ability.

This study offered the positive associations between *binding* foundations and cognitive ability. Notably, the associations were significantly moderated by the participants' age. These findings were novel, and additionally, suggested that the associations between moral values and cognitive ability could be modified by external factors. This study focused only on the participants' age as a moderator, however, future research should explore possible interactions between cognitive ability and other factors. In addition, the present findings implied that lower political interest predispose people to accept moral values that widely prevailed in their society without thinking. We can say that it is important to encourage younger people to get an interest in their society and politics in education.

Acknowledgements

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2019.05.050.

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