Do culture and oxytocin receptor polymorphisms interact to influence emotional expressivity?

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Abstract

Drawing on recent evidence suggesting that individuals having the G allele of the oxytocin receptor (OXTR) polymorphism are especially susceptible to socio- cultural environmental influences, including cultural norms, the present study investigated the interplay of culture and two OXTR polymorphisms (rs53576 and rs2254298) in the domain of emotional expressivity, which is culturally encouraged in Western cultures. Testing Japanese and European Canadian undergraduates, we found cultural differences in negative emotional expressivity and positive emotional expressivity. As expected, the European Canadians were greater in positive emotional expressivity than the Japanese. In contrast, the pattern was reversed in nega- tive emotional expressivity. A series of multiple regression analyses entering gen- der and personality traits as control variables showed that neither culture nor the two OXTR polymorphisms interact to negative emotional expressivity and positive emotional expressivity. The present null findings suggest that continued examination with larger samples would better elucidate results on the interactions among culture, OXTR, and socioemotional behaviors.

Introduction

Expressions of emotion are central to social life as they suggest communicative acts and regulate social interaction. While they are universally observed due to the adaptive functions, they also depend on cultural norms and practices. For example, people in individualistic cultures are more likely than those in collectivistic cultures to express emotions and endorse norms for emotional expressivity (Ekman 1972; Matsumoto et al. 2008). The cultural norms and practices that determine the appropriate expressions of emotion in certain circumstances are likely to be acquired in the process of socialization. On the other hand, evidence suggests that the acquisition of cultural norms and practices may interact with genetic factors (Ishii et al. 2014; Kim et al. 2010a, b, ; 2011; Kitayama et al. 2014; LeClair et al. 2016). People with particular genotypes may show more culturally divergent tendencies of behaviors than people with other genotypes. In the present study, we test European Canadian and Japanese students and address the interplay between genetic and cultural influences on emotional expressivity.

Previous research suggests the idea of gene-environmental interactions such that individuals' susceptibility to the environment is moderated by genetic variation (Belsky et al. 2007; Belsky et al. 2009; Obradović and Boyce 2009; Way and Taylor 2010). For example, Caspi and colleagues found that, compared to the long allele carriers of the serotonin transporter polymorphism (5-HTTLPR), individuals who are homozygous for the short allele of 5-HTTLPR were at greater risk for psychological disorders when experiencing a larger number of stressful life events (Caspi et al. 2003; see Karg et al. 2011; Miller et al. 2013 for meta-analyses; also see Culverhouse et al. 2018 for a recent critical meta-analysis). Individuals with the s/s genotype are thus more environmentally susceptive than l carriers. Gene-environment interactions have also been found with other genes, including the dopamine D4 receptor (DRD4) gene (e.g., Bakermans-Kranenburg and van Ijzendoorn 2006; Sasaki et al. 2013) and the oxytocin receptor (OXTR) gene (e.g., Thompson et al. 2011).

Recently, based on these gene-environment interaction studies, Kim and col- leagues have proposed a model incorporating cultural norms and practices in the notion of environment (Kim et al. 2010a, b, 2011; see Kim and Sasaki 2014; Sasaki and Kim 2017 for review). For instance, focusing on a polymorphism of the OXTR rs53576, Kim et al. (2010a) looked at emotional support seeking, which is considered a culturally normative behavior in North America, based on previous research (Kim et al. 2008; Taylor et al. 2004), and explored whether the culturally normative behavior would be subject to genetic influence. Oxytocin is implicated in regulating social behaviors, including social affiliation and attachment (see Heinrichs et al. 2009 for a review). OXTR rs53576 is a single-nucleotide polymorphism in the intron 3 region of OXTR. Previous studies showed that the G allele of OXTR rs53576 is associated with higher

empathic accuracy (Rodrigues et al. 2009) and prosocial temperament (Tost et al. 2010). Kim et al. (2010a) found that emotional support seeking was more evident in distressed North Americans having the G allele of a polymorphism of the OXTR rs53576 than in those with the AA genotype. However, such a relationship was not found in Koreans, for whom emotional support seeking is not a culturally normative behavior (Kim et al. 2010a). On the other hand, Kim et al. (2011) demonstrated that Koreans having the GG genotype were more likely than those having the AA genotype to report using emotional suppression, which is a more normative behavior in Korea. These findings suggest that cultural influences are more pronounced among G carriers (particularly those having the GG genotype) than those with the AA genotype of OXTR rs53576. Thus, individuals having the G allele of OXTR rs53576 are characterized as environmentally sensitive.

To our knowledge, the possibility that people having the G allele of OXTR rs53576 would be more likely to endorse culturally shared skills and behaviors, particularly socioemotional ones, has not been explored in the domain of emotional expressivity. Emotional expressivity is defined as “behavioral (e.g., facial, postural) changes that typically accompany emotion, such as smiling, frowning, crying, or storming out of the room” (Gross and John 1997, p. 435). The norms of emotional expressivity are tied closely to the cultural values of individualism and collectivism (Matsumoto et al. 2008) and long-history migration (Rychlowska et al. 2015); for example, greater emotional expressivity is associated with individualism and historical heterogeneity. Also, which functions of communication are emphasized depends on the cultural norms of emotional expressivity. In this respect, Scollon and Scollon (1995) suggested that the function of conveying information is likely to be emphasized in Western cultures (e.g., North America), whereas the function of maintain- ing relationships is likely to be emphasized in East Asian cultures (e.g., Japan). Expressing emotions is crucial to conveying information (e.g., one’s thoughts and feelings) to others, particularly in Western cultures. In contrast, as expressing emotions may sometimes disturb social relations, people in East Asian cultures are likely to be concerned with the negative consequences of expressing emotions and there- fore tend to suppress their emotions. Furthermore, Western cultures are more likely than East Asian cultures to value self-expression (Kim and Sherman 2007). Taken together, expressing emotions is normative in Western cultures, whereas suppressing emotions is normative in East Asian cultures. We thus hypothesized that European Canadians would be more likely than Japanese people to report emotional expressivity, and, as emotional expressivity is culturally encouraged, that European Canadians having the G allele of OXTR rs53576 would express emotions more than those having the A allele.

In addition, to date, no study has demonstrated evidence on the interaction between OXTR and culture by addressing the effect of another polymorphic variation of OXTR besides

OXTR rs53576. To address this gap, the present study also focuses on OXTR rs2254298, another single-nucleotide polymorphism in the intron 3 region of OXTR. Although the A allele (compared to the G allele) is minor for both OXTR rs53576 and OXTR rs2254298, the distribution differs across cultures. For both polymorphisms, A carriers are much less frequent in individuals of Euro- pean ancestry compared to Asians (for rs53576, Kim 2010a, 2011; LeClair et al. 2016; Luo and Han 2014; for rs2254298, Chelala et al. 2009). OXTR rs53576 and OXTR rs2254298 are frequently reported in terms of their associations with autism spectrum disorder (Kanat et al. 2014; Yamasue 2013), and the A allele is linked to atypical brain anatomy and reduced social skills (Inoue et al. 2010; LoParo and Waldman 2015). Based on the common characteristics, we also explored the possibility that OXTR rs2254298 and culture may interact to influence emotional expressivity in a similar way as OXTR rs53576 and culture do.

In the present study, we targeted two polymorphisms of OXTR (rs53576 and rs2254298) and investigated the gene-culture (Canada vs. Japan) interaction effect on emotional expressivity. We assessed emotional expressivity using the Berkeley Expressivity Questionnaire (BEQ; Gross and John 1997). The BEQ contains three facets: negative expressivity, consisting of six items (e.g., Whenever I feel negative emotions, people can easily see exactly what I am feeling), positive expressivity, consisting of four items (e.g., When I'm happy, my feelings show), and impulse strength, consisting of six items (e.g., I experience my emotions very strongly). Gross and John (1995) found the effects of gender, ethnic groups, and personality characteristics on the BEQ. For example, females were more likely than males to express emotions regardless of the facets. Asians and Asian Americans were less likely than European Americans to express emotions, although no difference was found for each of the facets (see also Tsai et al. 2000). Moreover, neuroticism and extraversion were highly associated with emotional expressivity. Specifically, nega- tive emotional expressivity was positively associated with neuroticism, whereas pos- itive emotional expressivity was positively associated with extraversion. Given these patterns, the present study investigated the interaction between gene and culture on emotional expressivity, while controlling for gender and personality characteristics. We predicted that for each of the two OXTR polymorphisms, European Canadians having the G allele would report emotional expressivity more than would those hav- ing the A allele, whereas such a genetic effect would be negligible in the Japanese.

Method

Participants and Procedures

Two hundred and twelve Japanese undergraduates at Kobe University (112 females and 100 males; M age=19.25, SD=0.99) and 249 European Canadian under- graduates at the University

of Alberta (166 females and 83 males; M age=19.42, SD=1.71) participated in the study. A power analysis based on the pwr package in R suggested that at least 408 participants were needed to detect a small/medium effect size (f2 = 0.04) with 80% power for a F test with three numerator degrees of freedom, when the significant level was set to 0.008 (=0.05/6 tested hypotheses [3 BEQ facets×2 polymorphisms]) based on the Bonferroni correction. The participants were recruited through a psychology subject pool in each of the universities. The Japanese students received 4000 yen (approximately USD 40) plus a bonus based on the results of money distribution tasks, whereas the Canadian students received course credit for their participation. Some tasks including the money distribution ones were conducted only for Japanese.

The experiment included the administration of questionnaires to the Japanese and Canadian participants on a wide range of topics, such as self, emotion, cognition, and interpersonal behaviors.1 The participants completed questionnaires measuring their emotional expressivity and the Big Five personality traits. Emotional expressivity was measured by the BEQ, which was translated and back-translated between Japanese and English to ensure cross-cultural equivalence. The participants were presented with each item and rated their agreement on a 7-point scale (1=strongly disagree, 7 = strongly agree). Cronbach's α for the BEQ total score, negative expressivity, positive expressivity, and impulse strength was between 0.67 and 0.85 among the Canadians and between 0.65 and 0.85 among the Japanese.2 The Big Five personality traits were measured by the NEO Five-Factor Inventory (Costa and McCrae 1997) with 12 items for each of the five personality traits (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness). For each trait, the score ranges from 0 to 48. The Japanese version of the scale (Shimonaka et al. 1999) was used for the Japanese participants. The reliabilities were reasonably high in both Japan and Canada (neuroticism: αs = 0.84 and 0.88; extraversion: αs = 0.81 and 0.81; openness to experience: αs=0.71 and 0.74; agreeableness: αs=0.72 and 0.81; and conscientiousness: αs = 0.80 and 0.86).

Genotyping

Nail samples were collected, from which genomic DNA was extracted using ISO- HAIR kits (NIPPON GENE CO., LTD, Tokyo, Japan). The SNP markers for OXTR (rs53576 and rs2254298) were genotyped using TaqMan® SNP Genotyping Assays (Thermo Fisher Scientific Inc., Waltham, Massachusetts), which were functionally tested by Thermo Fisher Scientific Inc. and available on demand. Each SNP assay contained forward and reverse polymerase chain reactions (PCR) primers as well as two allele specific probes conjugated with either the VIC or FAM fluorescent marker. Each PCR mixture consisted of DNA templates, the SNP-specific

Genotyping Assay, and Taqman Genotype master mix (Thermo Fisher Scientific Inc.). All PCR and allelic discrimination reactions were performed on the StepOne PlusTM Real-Time PCR System (Thermo Fisher Scientific Inc.).

Table 1 Descriptive statistics for the variables for each cultural group

Variable	Japanese		Canadians		Cultural difference
	M	*SD*	*M*	*SD*	
BEQ (total)	4.56	0.86	4.63	0.94	$F = 0.60, p = .44, \eta_p^2 = .001$
Negative expressivity	3.90	0.99	3.65	1.06	$F = 6.60, p = .01, \eta_p^2 = .01$
Positive expressivity	5.07	1.02	5.47	0.91	$F = 19.73, p < .001, \eta_p^2 = .04$
Impulse strength	4.72	1.09	4.77	1.38	$F = 0.14, p = .71, \eta_p^2 = .000$
Neuroticism	31.37	7.69	26.29	8.80	$F = 42.82, p < .001, \eta_p^2 = .09$
Extraversion	23.81	7.17	29.59	6.72	$F = 78.81, p < .001, \eta_p^2 = .15$
Openness	28.95	6.14	29.79	6.16	$F = 2.13, p = .15, \eta_p^2 = .005$
Agreeableness	28.76	5.82	31.28	7.01	$F = 17.23, p < .001, \eta_p^2 = .04$
Conscientiousness	24.84	6.92	30.45	7.22	$F = 71.85, p < .001, \eta_p^2 = .14$

Data from participants whose genotypes of the two OXTR polymorphisms were undetermined were included to compute mean scores of these variables and test the cultural differences

Results

Genotype distribution

For both polymorphisms, the distribution of genotypes was different between the Canadians (rs53576: 29 AA, 97 AG, 106 GG, 17 undetermined; rs2254298: 0 AA, 40 AG, 198 GG, 11 undetermined) and the Japanese (rs53576: 89 AA, 84 AG, 32 GG; 7 undetermined, rs2254298: 16 AA, 85 AG, 104 GG, 7 undetermined), $\chi2(2)=69.72$, $p<0.001$ for rs53576; $\chi2(2)=59.33$, $p<0.001$ for rs2254298. The distribution was not different from that predicted by the Hardy–Weinberg equilibrium in either cultural group (rs53576: $\chi2(1)=0.84$, $p=0.36$ for the Canadians; $\chi2(1)=2.56$, $p=0.11$ for the Japanese; rs2254298: $\chi2(1)=2.00$, $p=0.16$ for the Canadians; $\chi2(1) = 0.06$, $p = 0.81$ for the Japanese).

Predictors of emotional expressivity

Table 1 shows the descriptive statistics for the variables for each cultural group. The Japanese were significantly higher in negative emotional expressivity, F(1, 460)=6.60, p=0.01, ηp2=0.01, whereas the Canadians were significantly higher in positive emotional expressivity, F(1, 460)=19.73, p<0.001, ηp2=0.04. Impulse strength did not differ between the cultures, F(1, 460)=0.14, p=0.71, ηp2=0.000. Accordingly, no cultural difference was found in the total mean score of the BEQ, F(1, 460)=0.60, p=0.44, ηp2=0.001. In addition, the Japanese were significantly higher than the Canadians in neuroticism, F(1, 459)=42.82, p<0.001, ηp2=0.09, whereas the Canadians were significantly higher than the Japanese in extraversion, F(1, 459)=78.81, p<0.001, ηp2=0.15, agreeableness, F(1, 459)=17.23, p<0.001, ηp2=0.04, and

Table 2 Correlations among the variables for Japanese and Canadian participants

Variable	1	2	3	4	5	6	7	8	9
1. BEQ (total)	–	.84***	.86***	.82***	.32***	.28***	.15*	.10	− .16*
2. Negative expressivity	.84***	–	.64***	.49***	.29***	.15*	− .04	.06	− .19**
3. Positive expressivity	.78***	.53***	–	.54***	.10	.43***	.11	.17*	− .05
4. Impulse strength	.89***	.60***	.53**	–	.40***	.11^{+}	.29***	.01	− .15*
5. Neuroticism	.40***	.32***	.14*	.47***	–	− .32***	− .08	− .22**	− .23***
6. Extraversion	.20**	.09	.41***	.08	− .28***	–	.15*	.40***	.26***
7. Openness	.21***	.03	.18**	.30***	.23***	− .07	–	.05	− .08
8. Agreeableness	.17**	.07	.19**	.17**	− .04	.11^{+}	.21**	–	.15*
9. Conscientiousness	− .07	− .04	− .02	− .10	− .38***	.15*	− .16*	.14*	–

Correlations for Japanese are presented above the diagonal, and correlations for Canadian are presented below the diagonal. ***$p < .001$, **$p < .01$, *$p < .05$, $^{+}p < .10$

conscientiousness, F(1, 459)=71.85, p<0.001, ηp2=0.14. Open- ness did not differ between Canadians and Japanese, F(1, 459)=2.13, p=0.15, ηp2=0.005. In both cultures, the total mean score of the BEQ was significantly positively associated with neuroticism (Canada: r=0.40, p<0.001, Japan: r=0.32, p < 0.001), extraversion (Canada: r = 0.20, p = 0.001, Japan: r = 0.28, p < 0.001), and openness (Canada: r=0.21, p<0.001, Japan: r=0.15, p=0.03). For each facet of the BEQ, negative emotional expressivity was positively associated with neuroticism (Canada: r=0.32, p<0.001, Japan: r=0.29, p<0.001), while positive emotional expressivity was positively associated with extraversion (Canada: r=0.41, p < 0.001, Japan: r = 0.43, p < 0.001) and agreeableness (Canada: r = 0.19, p = 0.003, Japan: r=0.17, p=0.01). Impulse strength was positively associated with neuroticism (Canada: r = 0.47, p < 0.001, Japan: r = 0.40, p < 0.001)

and openness (Canada: r=0.30, p<0.001, Japan: r=0.29, p<0.001) (see Table 2). Overall, these patterns of the associations between the BEQ and personality traits were consistent with the previous findings (Gross and John 1995).

Mean scores of BEQ total and its three facets as a function of culture and OXTR were shown in Table 3 (OXTR rs53576) and Table 4 (OXTR rs2254298). As culture influenced both negative emotional expressivity and positive emotional expressivity, a series of multiple regression analyses were conducted for each of the two emotional expressivity facets. In case of OXTR rs53576, gender (male=0, female=1) and personality (neuroticism, extraversion, openness, agreeableness, and conscientiousness) were entered along with the key variables (i.e., culture [Japanese=0, Canadians=1] and two OXTR dummy codes) (Step 1). The two OXTR dummy codes consisted of (a) GG (1) versus AA (0) and (b) AG (1) versus AA (0). Second, the interactions with culture and the two OXTR dummy codes were addition- ally entered (Step 2). In case of OXTR rs2254298, because there was no European Canadian having the AA genotype, two variables (A carriers: 0, GG: 1) were used. The key variables (culture and OXTR) and the control variables (gender and personality traits) were entered (Step 1). Then, the interaction between culture and OXTR was added (Step 2).

Table 3 Mean scores of total BEQ and its facets (negative expressivity, positive expressivity, and impulse strength) reported by Canadians and Japanese with OXTR rs53576 AA, AG, and GG genotypes

	BEQ (total)		Negative expressiv- ity		Positive expressiv- ity		Impulse strength	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Canada								
AA (n=29)	4.73	1.05	3.84	1.25	5.53	0.87	4.81	1.54
AG (n=97)	4.55	0.91	3.55	1.04	5.47	0.92	4.64	1.35
GG (n=106)	4.62	0.95	3.66	1.02	5.39	0.93	4.81	1.40
Japan								
AA (n=89)	4.70	0.86	4.08	0.92	5.15	0.98	4.86	1.10
AG (n=84)	4.48	0.83	3.78	0.96	4.99	1.05	4.67	1.08
GG (n=32)	4.49	0.94	3.82	1.18	5.11	1.08	4.54	1.01

Table 4 Mean scores of total BEQ and its facets (negative expressivity, positive expressivity, and impulse strength) reported by Canadians and Japanese with OXTR rs2254298 AA, AG, and GG genotypes

	BEQ (total)		Negative Expres- sivity		Positive Expres- sivity		Impulse Strength	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Canada								
AG (n=40)	4.56	1.19	3.69	1.26	5.41	1.06	4.57	1.61
GG (n=198)	4.63	0.89	3.64	1.02	5.46	0.88	4.78	1.33
Japan								
AA (n=16)	4.90	0.51	4.24	0.78	5.22	0.72	5.25	0.74
AG (n=85)	4.54	0.98	3.92	1.05	5.09	1.14	4.63	1.18
GG (n=104)	4.53	0.82	3.86	0.96	5.05	0.99	4.68	1.03

OXTRrs53576

In the analysis of negative emotional expressivity (Table 5), the main effects of neuroticism (b=0.04, standard error (SE)=0.01, t(427)=6.93, p<0.001) and extraversion (b=0.03, SE=0.01, t(427)=4.61, p<0.001) were significant in Step 1. The same pattern also appeared in Step 2. However, any effect including OXTR was not significant (Fig. 1a). In the analysis of positive emotional expressivity (Table 6), the main effects of neuroticism (b=0.02, SE=0.01, t(427)=4.34, p<0.001) and extra- version (b=0.07, SE=0.01, t(427)=10.93, p<0.001) were significant. The same pattern also appeared in Step 2. However, any effect including OXTR was not sig- nificant (Fig. 1b).

OXTR rs2254298

In the analysis of negative emotional expressivity (Table 7), the main effects of neuroticism (b=0.04, SE=0.01, t(434)=7.01, p<0.001) and extraversion (b=0.03, SE=0.01, t(434)=4.45,

Table 5 The results of a series of multiple regressions predicting negative expressivity including culture and OXTR rs53576

Predictors	Step 1 (R^2 = .183)				Step 2 (ΔR^2 = .001)			
	b	SE	*t*(427)	*p*	*b*	SE	*t*(425)	*p*
Culture (0: Jpn, 1: Can)	0.16	0.11	1.47	.14	0.13	0.21	0.59	.56
OXTR1 (0: AA, 1: GG)	− 0.22	0.13	− 1.72	.09	− 0.23	0.20	− 1.13	.26
OXTR2 (0: AA, 1: AG)	− 0.26	0.12	− 2.28	.02	− 0.33	0.20	− 1.65	.10
Neuroticism	0.04	0.01	6.93	< .001	0.04	0.01	6.92	< .001
Extraversion	0.03	0.01	4.61	< .001	0.03	0.01	4.65	< .001
Openness	− 0.01	0.01	− 1.47	.14	− 0.01	0.01	− 1.50	.14
Agreeableness	0.01	0.01	0.92	.36	0.01	0.01	0.88	.38
Conscientiousness	− 0.01	0.01	− 0.85	.39	− 0.01	0.01	− 0.87	.39
Gender (0: M, 1: F)	0.21	0.10	2.14	.03	0.22	0.10	2.19	.03
Culture × OXTR1					− 0.08	0.28	− 0.29	.78
Culture × OXTR2					0.12	0.25	0.48	.63

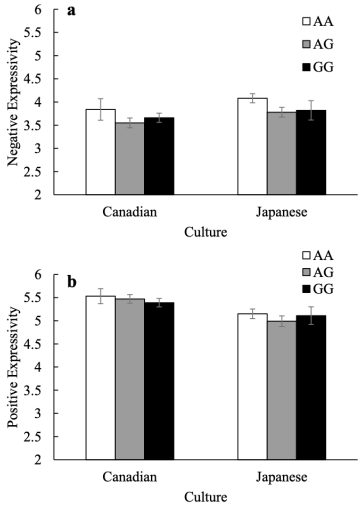

Fig. 1 Non-significant interaction between culture and OXTR rs53576 on negative expressivity (**a**) and positive expressivity (**b**)

p<0.001) were significant. The same pattern also appeared in Step 2. However, any effect including OXTR was not significant (Fig. 2a). In the analysis of positive emotional expressivity (Table 8), the main effects of neuroticism (b = 0.02, SE = 0.01, t(434) = 4.49, p < 0.001) and extraversion (b=0.07, SE=0.01, t(434)=10.64, p<0.001) were significant. The same pattern also appeared in Step 2. However, any effect including OXTR was not significant (Fig. 2b).

Table 6 The results of a series of multiple regressions predicting positive expressivity including culture and OXTR rs53576

Predictors	Step 1 (R^2 = .305)				Step 2 (ΔR^2 = .0003)			
	b	SE	*t*(427)	*p*	*b*	*SE*	*t*(425)	*p*
Culture (0: Jpn, 1: Can)	− 0.13	0.10	− 1.29	.20	− 0.06	0.19	− 0.31	.76
OXTR1 (0: AA, 1: GG)	− 0.12	0.11	− 1.01	.31	− 0.07	0.18	− 0.38	.71
OXTR2 (0: AA, 1: AG)	− 0.11	0.10	− 1.10	.27	− 0.05	0.18	− 0.28	.78
Neuroticism	0.02	0.01	4.34	< .001	0.02	0.01	4.29	< .001
Extraversion	0.07	0.01	10.93	< .001	0.07	0.01	10.87	< .001
Openness	0.01	0.01	1.98	.05	0.01	0.01	2.01	.04
Agreeableness	0.01	0.01	1.76	.08	0.01	0.01	1.75	.08
Conscientiousness	− 0.01	0.01	− 1.30	.20	− 0.01	0.01	− 1.28	.20
Gender (0: M, 1: F)	0.19	0.09	2.19	.03	0.19	0.09	2.18	.03
Culture × OXTR1					− 0.07	0.25	− 0.28	.78
Culture × OXTR2					− 0.09	0.22	− 0.43	.67

Table 7 The results of a series of multiple regressions predicting negative expressivity including culture and OXTR rs2254298

Predictors	Step 1 (R^2 = .171)				Step 2 (ΔR^2 = .0001)			
	b	*SE*	*t*(434)	*p*	*b*	*SE*	*t*(433)	*p*
Culture (0: Jpn, 1: Can)	− 0.18	0.11	− 1.66	.10	− 0.23	0.19	− 1.20	.23
OXTR (0: A, 1: GG)	− 0.08	0.10	− 0.76	.45	− 0.10	0.13	− 0.77	.44
Neuroticism	0.04	0.01	7.01	< .001	0.04	0.01	7.00	< .001
Extraversion	0.03	0.01	4.45	< .001	0.03	0.01	4.45	< .001
Openness	− 0.01	0.01	− 1.41	.16	− 0.01	0.01	− 1.43	.15
Agreeableness	0.01	0.01	1.10	.27	0.01	0.01	1.09	.27
Conscientiousness	− 0.01	0.01	− 1.21	.23	− 0.01	0.01	− 1.20	.23
Gender (0: M, 1: F)	0.19	0.10	1.97	.05	0.19	0.10	1.97	.05
Culture × OXTR					0.06	0.21	0.28	.78

Discussion

Based on the gene-culture framework that individual differences with respect to the acquisition of culturally normative behaviors interact with genetic factors, we hypothesized that OXTR polymorphisms would moderate cultural differences in emotional expressivity. Because previous research suggested that expressing emotions is normative in Western cultures, and that individuals having the G allele of OXTR rs53576 are characterized as environmentally sensitive, we expected that European Canadians having the G allele would report emotional expressivity more than would those having the A allele, whereas such a genetic effect would be negligible in the Japanese. Controlling the potential effects of gender and personality traits, we tested the hypotheses by using not only OXTR rs53576, but also OXTR rs2254298, which is frequently reported with respect to social behavior and autism as well as OXTR rs53576. The results, however, did not support any hypothesis. Neither the main effects of the two OXTR polymorphisms nor the interactions with culture was found for any facet of emotional expressivity.

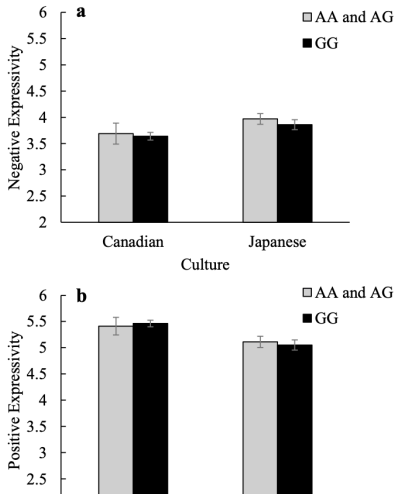

Fig. 2 Non-significant interaction between culture and OXTR rs2254298 on negative expressivity (**a**) and positive expressivity (**b**)

Table 8 The results of a series of multiple regressions predicting positive expressivity including culture and OXTR rs2254298

Predictors	Step 1 ($R^2 = .294$)				Step 2 ($\Delta R^2 = .0003$)			
	b	*SE*	*t*(434)	*p*	*b*	*SE*	*t*(433)	*p*
Culture (0: Jpn, 1: Can)	0.11	0.10	1.11	.27	0.05	0.16	0.28	.78
OXTR (0: A, 1: GG)	0.00	0.09	0.02	.98	− 0.03	0.12	− 0.28	.78
Neuroticism	0.02	0.01	4.49	< .001	0.02	0.01	4.48	< .001
Extraversion	0.07	0.01	10.64	< .001	0.07	0.01	10.64	< .001
Openness	0.01	0.01	2.07	.04	0.01	0.01	2.02	.04
Agreeableness	0.01	0.01	1.76	.08	0.01	0.01	1.76	.08
Conscientiousness	− 0.01	0.01	− 1.36	.17	− 0.01	0.01	− 1.34	.18
Gender (0: M, 1: F)	0.19	0.09	2.22	.03	0.19	0.09	2.23	.03
Culture × OXTR					0.09	0.19	0.47	.64

Previous research demonstrated that OXTR rs53576 moderated cultural differences in emotional support seeking (Kim et al. 2010a) and emotion regulation (Kim et al. 2011), whereas in this research either OXTR rs53576 or OXTR rs2254298 did not moderate cultural differences in negative emotional expressivity and positive emotional expressivity. Although the inconsistency among these findings may reflect differences in the characteristics of socioemotional behaviors and skills measured among the studies, it may also be that the findings were based on studies with relatively low statistical power. Compared to the previous studies by Kim and col- leagues, the sample size of this research was larger and fulfilled a required number of participants computed by a power analysis. Further follow-up studies with a larger sample size, which incorporate multiple measurements of socioemotional behaviors, are needed to find consistent results on the interactions among culture, OXTR, and socioemotional behaviors and reach a credible conclusion.

This study used the BEQ as a measurement of emotional expressivity and found the expected influences of personality. Higher neuroticism, extraversion, and open- ness led to a greater mean score of the BEQ in both cultures. Specifically, negative emotional expressivity was positively associated with neuroticism, while positive emotional expressivity was positively associated with extraversion and agreeable- ness. On the other hand, the influence of culture was limited to only negative and positive emotional expressivity. As expected, the European Canadians were greater in positive emotional expressivity than the Japanese. In contrast, unexpectedly, the pattern was reversed in negative emotional expressivity. Given the positive correlation between neuroticism and negative emotional expressivity, the greater level of neuroticism in the Japanese than in the European Canadians might have caused the unexpected pattern. As another possibility, the Japanese may report less negative emotional expressivity only in a specific situation, not in general. For instance, when Japanese and Americans were presented with highly stressful films, they expressed their negative emotions when they were alone. In contrast, when they were in the presence of an older male experimenter, the Americans still expressed the negative emotions, whereas the Japanese masked the negative emotions and instead smiled (Ekman 1972). This suggests that the display rule shared among the Japanese depends on with whom they are interacting. On the other hand, the items of the BEQ do not specify social situations and types of interactions, but rather measure emotional expressivity over various situations. Thus, the BEQ might be inappropriate to measure cultural differences in negative emotional expressivity that heavily depends on social situations and types of interactions.

The present study includes some limitations to be addressed in future work. First, although Gross and John (1997) indicated that individuals' expressive behaviors were predicted by negative and positive emotional expressivity measured by the BEQ (e.g., individuals reporting higher negative emotional expressivity were more likely to express sadness when they were exposed to a sad film), as the present study relied on only a self-report measure (i.e., the BEQ), it is unclear whether and to what extent gene and culture interact to influence the actual behaviors of emotional expression. Second, although OXTR rs53576 and rs2254298 share the functions of social affiliation and are some of the most popular OXTR polymorphisms that have been examined in the literature, the selection might be somewhat arbitrary as their functional effects at the molecular level were less considered. Indeed, the functionality of the two polymorphisms of OXTR is not clear, because they are located in an untranslated region. As Brüne (2012) pointed out, it is also unclear how the OXTR polymorphisms translate into the actual availability of oxytocin in the brain. Future research with a set of polymorphisms sharing the same neurotransmitter signaling system in the framework of gene-culture interactions would be desirable for interpreting the effect of genes in a precise manner.

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Compliance with ethical standards

Ethics approval The study was reviewed and approved by the ethics committees at Kobe University and the University of Alberta. The participants provided a written informed consent at the beginning of the study. All responses were confidential.

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