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SUPPLEMENT

Supplementary information for: Embodied emotional expressions for intuitive experience sampling methods: A demographic investigation with Japanese speakers

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Table S1. Questionnaire items

Emotion	English	Japanese
	Please select all the expressions that apply to you…	下記について、あてはまるものを全てお選びください。
Joy:		
High	when you are ecstatic and when you feel strong joy	有頂天になっているとき、すごく嬉しいときの表現について
Medium	when you feel joy	喜んでいるときの表現について
Low	when your heart is calm	安らぎを感じているときの表現について
Sadness:		
High	when you are mourning	嘆き悲しんでいるときの表現について
Medium	when you are sad	悲しいときの表現について
Low	when you are a little depressed	気分がやや沈んでいるときの表現について
Anticipation:		
High	when you are wary of something	何かに対して過敏になっているときの表現について
Medium	when you have anticipations	何かの予感を感じるときの表現について
Low	when you have something on your mind	何か気になることがあるときの表現について
Surprise:		
High	when you are very surprised	すごく驚いているときの表現について
Medium:	when you are surprised	驚いているときの表現について
Low	when you are distracted	落ち着かないときの表現について
Anger:		
High	when you are indignant	激怒しているときの表現について
Medium	when you get angry	怒っているときの表現について
Low	when you are annoyed	気に障ることがあるときの表現について
Fear:		
High	when you are so scared	すごく怖いときの表現について
Medium	when you feel afraid	怖いときの表現について
Low	when you feel anxious	不安なときの表現について
Disgust:		
High	when you have a strong disgust	強い嫌悪感があるときの表現について
Medium	when you are uncomfortable	不快なときの表現について
Low	when you are boring	つまらないときの表現について
Trust:		
High	when you have longing and respect	憧れや尊敬の念を抱いているときの表現について
Medium	when you have a positive feeling	好感を感じるときの表現について
Low	when you are accepting	受け入れるときの表現について

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1. Data analysis

1.1 Correspondence analysis of the relationship between emotional intensity and EEEs

To determine the patterns of EEE use when describing emotions and feelings, the survey results were analyzed using a data visualization method called correspondence analysis. Correspondence analysis allowed us to produce a visual representation of the overall use patterns of EEE according to the intensity of emotion, something that cannot be captured in a pairwise test of association. This method has been widely used in psychology, sociology, and corpus linguistics research (Bakker, 1993; Burton et al., 2005).

Correspondence analysis involves projecting categorical data in a multidimensional map, a process underpinned by three main concepts: (1) profile, (2) mass (or weight), and (3) chi-square distance.

(1) Profile: a profile for a row or column item is determined by taking each row or column and dividing it by the sum of all rows or columns. The row/column profiles define the row and column items in the biplot.

(2) Mass: because every item is not equally important, the weighted averages (i.e., mass of the profiles) are used to measure the importance of the item. For example, the row mass is the sum of the row items divided by the grand total.

(3) Chi-square distance: chi-square distances determine the distances between items (e.g., row items) and these distances are used to represent the data in the map, giving a measure of the similarity (or dissimilarity) among row items or among column items.

Each dimension on the multidimensional map represents a certain percentage of the structuring of the data variation. Normally, a combination of the first two dimensions captures a large percentage of the variation (i.e., there are two dimensions in a biplot). The total variation in correspondence analysis can be measured by the total inertia. It is suggested that additional dimensions should be added if the total inertia for the first two dimensions is less than 75% (Glynn, 2014).

There are different ways to represent the data in a biplot, the most common of which is known as the symmetric biplot. In the symmetric biplot, the row and column items are plotted in principal coordinates, which are the coordinates on the same axes of the map. In this case, only the distances between row items or the distances between column items can be interpreted.

To explore the relationship between EEE use and emotional intensity using correspondence analysis, we first converted the raw data from the survey to a contingency table. The visualized contingency table for the use-frequencies of EEEs in the emotional category "joy" is shown in Figure S1. This figure summarizes the distribution of each EEE chosen at different emotional intensities. The larger the size of the dot, the more frequently the EEE was chosen. It can be seen clearly from the visualized contingency table that the use-frequency of EEEs was quite different at low emotional intensity compared with high and medium intensities. Overall, EEEs were used more frequently at high and medium emotional intensities. A Pearson chi-square statistic (X^2) showed a statistically significant association between EEE and emotional intensity ($p < 0.0001$). However, it did not show how the two variables were related. We examined the association using correspondence analysis and explained each of the main concepts (i.e., profile, mass, and chi-square distance) in turn.

As stated above, the first concept, "profile," is a vector that each row/column divided by its row/column total (see Tables S2 and S3). Row profiles correspond to the relative frequencies of different emotional intensities within each EEE. The average row profile, presented in the bottom row of Table S2, is the marginal frequency distribution over the sum of the rows. In our example,

the average row profile shows that, when pooling across all EEEs, the use of EEE was dominant at high emotional intensity, while using EEEs to describe "joy" at low emotional intensity was the least common. Likewise, column profiles are the relative frequencies of the different EEEs within each emotional intensity (Table S3).

Each row/column profile is then given a weight, which measures the importance of the row/column item (i.e., the row/column mass). The row/column mass is the frequency of the row/column divided by the grand total.

Finally, the chi-square distances between row/column items were measured. It should be noted that distances are only defined within the EEEs (rows) or within the emotional intensities (columns), not across the rows and columns. The equations for calculating the chi-square distances between row items or column items are as follows:

$$d\,(row_1, row_2) = \sqrt{\sum \frac{(row.profile_1 - row.profile_2)^2}{average.profile}}$$

$$d\,(column_1, column_2) = \sqrt{\sum \frac{(column.profile_1 - column.profile_2)^2}{average.profile}}$$

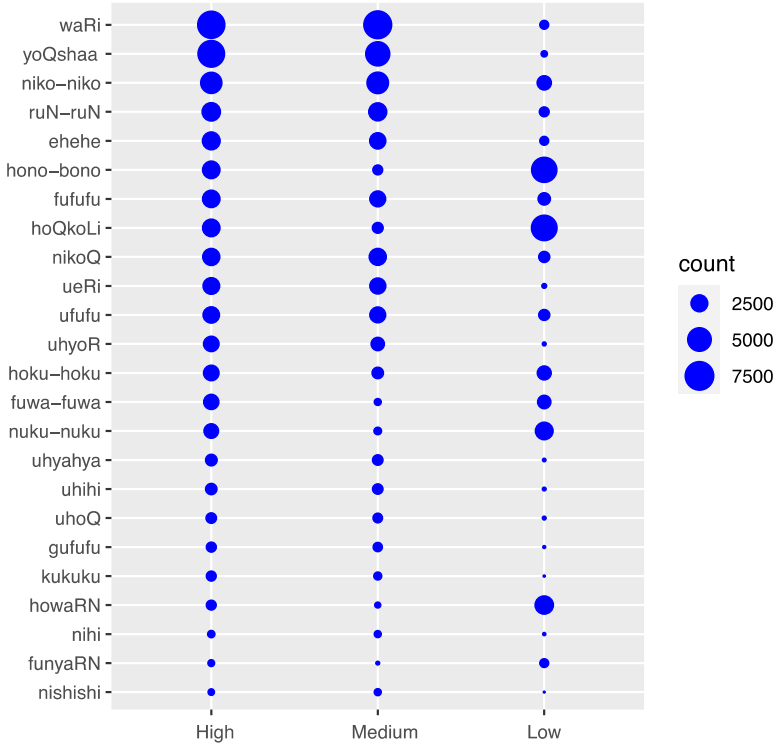
For example, the chi-square distance between row item "uhyoR" (うひょー) and "waRi" (わーい) is:

$$d\,(row_1, row_2) = \sqrt{\frac{(0.539 - 0.464)^2}{0.428} + \frac{(0.399 - 0.487)^2}{0.329} + \frac{(0.062 - 0.049)^2}{0.242}} = 0.193$$

To construct a biplot, correspondence analysis decomposes the inertia by identifying two mutually independent dimensions that represent the most important deviations from independence. The total inertia is equal to the Pearson chi-square (X^2) statistic divided by the grand total. In the biplot, the largest amount of explained inertia is represented by the first dimension, and the second largest by the second dimension. Each dimension has an eigenvalue which represents its relative importance and how much of the inertia it explains.

As mentioned above, the distance between any row and column in a symmetric biplot is only meaningful enough to support a general statement about the observed pattern. Therefore, we also estimated the association between row items and column items by interpreting the standardized residuals of rows and columns following a visual inspection of the plotted biplots.

Fig S1. Visualized contingency table of EEE by emotional intensity (emotion: joy)



Note: The sizes of the blue dots represent the relative proportion of EEE use-frequency to the total

Table S2. Row profiles for EEEs by emotional intensity (emotion: joy)

	Emotional intensity			
EEE	Low	Medium	High	Total
waRi	**0.464**	**0.487**	**0.049**	1.000
yoQshaa	0.534	0.434	0.032	1.000
niko-niko	0.404	0.418	0.178	1.000
ruN-ruN	0.450	0.426	0.124	1.000
ehehe	0.481	0.398	0.121	1.000
hono-bono	0.289	0.091	0.619	1.000
fufufu	0.435	0.353	0.213	1.000
hoQkoLi	0.279	0.106	0.615	1.000
nikoQ	0.415	0.412	0.173	1.000
ueRi	0.490	0.452	0.059	1.000
ufufu	0.420	0.393	0.187	1.000
uhyoR	**0.539**	**0.399**	**0.062**	1.000
hoku-hoku	0.424	0.235	0.341	1.000
fuwa-fuwa	0.501	0.114	0.384	1.000
nuku-nuku	0.362	0.103	0.535	1.000
uhyahya	0.494	0.409	0.097	1.000
uhihi	0.487	0.412	0.102	1.000
uhoQ	0.478	0.403	0.119	1.000
gufufu	0.478	0.409	0.113	1.000
kukuku	0.529	0.352	0.119	1.000
howaRN	0.203	0.088	0.709	1.000
nihi	0.414	0.406	0.180	1.000
funyaRN	0.325	0.170	0.505	1.000
nishishi	0.384	0.435	0.182	1.000
Average profile	**0.428**	**0.329**	**0.242**	1.000

Table S3. Column profiles for EEEs by emotional intensity (emotion: joy)

	Emotional intensity			
EEE	Low	Medium	High	Average
waRi	0.126	0.169	0.023	0.106
yoQshaa	0.120	0.125	0.013	0.086
niko-niko	0.075	0.099	0.057	0.077
ruN-ruN	0.056	0.068	0.027	0.050
ehehe	0.052	0.055	0.023	0.043
hono-bono	0.050	0.020	0.185	0.085
fufufu	0.050	0.052	0.042	0.048
hoQkoLi	0.050	0.024	0.190	0.088
nikoQ	0.048	0.061	0.034	0.048
ueRi	0.045	0.053	0.009	0.036
ufufu	0.044	0.052	0.034	0.043
uhyoR	0.039	0.037	0.008	0.028
hoku-hoku	0.039	0.027	0.054	0.040
fuwa-fuwa	0.038	0.011	0.050	0.033
nuku-nuku	0.034	0.012	0.088	0.045
uhyahya	0.022	0.023	0.007	0.017
uhihi	0.021	0.022	0.007	0.017
uhoQ	0.018	0.019	0.008	0.015
gufufu	0.016	0.018	0.007	0.014
kukuku	0.016	0.014	0.006	0.012
howaRN	0.016	0.009	0.095	0.040
nihi	0.009	0.011	0.007	0.009
funyaRN	0.008	0.005	0.022	0.012
nishishi	0.008	0.011	0.006	0.008
Total	1.000	1.000	1.000	1.000

2. Supplementary results

2.1 Similarity of EEEs within gender-age groups

Table S4. Top three EEEs for trust chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	uQtoLi	26.8	uQtoLi	31.9	uQtoLi	37.3	uQtoLi	43.4	uQtoLi	46.7
		kira-kira	23.2	oo	22.6	oo	22.2	oo	22.8	oo	22.1
		oo	22.7	kira-kira	22.4	kira-kira	17.1	kyuN-kyuN	17.3	kyuN	20.2
	Man	oo	22.5	oo	22.2	oo	21.2	uQtoLi	24.3	uQtoLi	34.1
		uQtoLi	13.3	uQtoLi	18.2	uQtoLi	20.3	oo	21.1	oo	20.9
		kira-kira	12.5	hou	11.5	hohou	11.3	hohou	14.3	hou	18.4
Medium	Woman	kyuN	28.7	kyuN	24.9	uQtoLi	25.3	uQtoLi	29.5	uQtoLi	32.0
		kyuN-kyuN	24.5	uQtoLi	24.5	kyuN	20.9	uN-uN	23.4	uN-uN	27.5
		uQtoLi	20.7	kyuN-kyuN	21.8	uN-uN	17.1	kyuN	21.3	kyuN	20.7
	Man	oo	15.4	oo	16.8	uQtoLi	18.0	uQtoLi	19.8	uQtoLi	25.6
		uQtoLi	14.0	uQtoLi	15.8	oo	15.5	uN-uN	16.9	uN-uN	22.0
		uN-uN	13.7	uN-uN	15.0	uN-uN	13.6	oo	14.4	hou	16.1
Low	Woman	uN-uN	42.9	uN-uN	46.6	uN-uN	47.5	uN-uN	52.6	uN-uN	51.2
		uN	38.4	uN	40.7	uN	40.4	uN	39.8	uN	41.1
		hou-hou	19.0	fumu-fumu	16.9	fumu-fumu	15.9	fumu-fumu	19.7	fumu-fumu	19.1
	Man	uN-uN	30.6	uN-uN	28.4	uN-uN	29.7	uN-uN	31.8	uN-uN	40.0
		uN	26.7	uN	25.5	uN	25.8	uN	29.7	uN	36.3
		umu	13.8	umu	14.4	umu	14.6	fumu-fumu	15.0	fumu-fumu	16.6

Table S5. Top three EEEs for disgust chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	uwaa	27.2	geQ	28.0	geQ	26.9	geQ	29.5	geQ	23.6
		oeR	23.9	gee	24.9	gee	21.1	gegeQ	24.1	gee	23.4
		ueR	20.6	uwaa	21.8	oeR	20.0	gee	21.6	oeR	20.9
	Man	uwaa	16.2	gee	16.1	oeR	15.2	oeR	17.8	gee	18.7
		oeR	15.9	oeR	15.1	gee	13.9	geQ	17.1	geQ	18.7
		gee	14.1	geQ	14.8	ugeQ	13.8	gee	16.9	oeR	18.1
Medium	Woman	uwaa	24.6	geQ	24.8	geQ	21.6	geQ	23.0	aRa	23.3
		ueR	21.8	gee	21.1	oeR	17.0	haRa	19.6	haRa	20.5
		oeR	21.1	haa	19.8	haa	15.9	aRa	17.4	haa	18.4
	Man	uwaa	16.1	gee	14.4	oeR	14.5	oi-oi	14.8	oi-oi	20.8
		oeR	15.3	geQ	13.7	oi-oi	13.5	geQ	14.3	cheQ	18.9
		haa	12.7	uwaa	12.9	gee	11.9	gee	14.1	yare-yare	17.3
Low	Woman	haRa	35.6	haRa	38.7	aRa	33.8	aRa	40.0	aRa	46.9
		haa	32.1	aRa	34.3	haRa	31.6	haRa	34.0	haRa	32.2
		aRa	28.0	haa	32.2	haa	26.9	haa	28.7	yare-yare	30.2
	Man	haRa	24.1	haRa	24.6	haRa	22.4	aRa	28.6	aRa	36.7
		haa	21.9	haa	21.7	aRa	22.1	cheQ	24.6	yare-yare	29.4
		aRa	19.8	aRa	20.7	haa	20.5	haRa	22.8	cheQ	25.4

Table S6. Top three EEEs for anticipation chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	eQ	32.1	sowa-sowa	30.9	piri-piri	33.3	piri-piri	38.9	piri-piri	45.7
		sowa-sowa	31.2	doki-doki	30.4	doki-doki	29.0	doki-doki	33.7	doki-doki	36.8
		doki-doki	28.0	biku-biku	30.4	biku-biku	28.0	biku-biku	32.2	biku-biku	34.9
	Man	piri-piri	20.5	piri-piri	23.4	piri-piri	26.0	piri-piri	33.7	piri-piri	40.0
		biku-biku	18.7	biku-biku	19.9	biku-biku	20.7	biku-biku	23.0	doki-doki	27.5
		eQ	18.0	bikuQ	18.2	doki-doki	19.0	doki-doki	22.5	biku-biku	25.0
Medium	Woman	sowa-sowa	28.9	sowa-sowa	31.3	sowa-sowa	26.4	sowa-sowa	29.9	zawa-zawa	27.9
		zawa-zawa	24.3	doki-doki	24.7	doki-doki	23.8	zawa-zawa	27.1	sowa-sowa	27.3
		doki-doki	21.3	zawa-zawa	24.0	zawa-zawa	23.6	waku-waku	25.0	doki-doki	25.9
	Man	sowa-sowa	18.7	sowa-sowa	18.7	zawa-zawa	17.1	waku-waku	20.2	waku-waku	23.1
		zawa-zawa	18.6	zawa-zawa	17.5	sowa-sowa	15.5	sowa-sowa	19.4	sowa-sowa	19.7
		doki-doki	14.2	doki-doki	15.6	waku-waku	14.6	zawa-zawa	17.4	oya	18.2
Low	Woman	sowa-sowa	27.7	sowa-sowa	32.1	sowa-sowa	33.8	sowa-sowa	36.1	sowa-sowa	38.3
		eQ	22.3	eQ	21.5	doki-doki	22.0	doki-doki	24.0	doki-doki	25.5
		doki-doki	16.7	doki-doki	18.8	zawa-zawa	16.8	eQ	18.0	hara-hara	22.5
	Man	sowa-sowa	19.5	sowa-sowa	20.2	sowa-sowa	21.9	sowa-sowa	26.6	sowa-sowa	26.7
		eQ	16.2	oya	17.0	oya	16.4	oya	17.2	oya	22.8
		oya	15.1	eQ	14.8	doki-doki	13.2	doki-doki	14.6	eQ	18.1

Table S7. Top three EEEs for surprise chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	eR	38.8	eR	43.8	eR	37.5	eR	44.2	eR	39.4
		waa	33.4	waa	31.9	kyaa	28.7	hieR	37.1	gyoQ	34.0
		kyaa	27.7	kyaa	31.7	hieR	27.5	kyaa	33.6	hieR	33.9
	Man	eR	19.8	eR	22.9	eR	22.3	eR	26.3	gyoQ	32.4
		ooo	19.7	ooo	20.8	ooo	18.5	hieR	23.5	eR	27.2
		waa	15.8	dokiQ	17.0	gyoQ	16.9	gyoQ	23.0	hieR	25.4
Medium	Woman	eR	36.0	eR	44.0	eR	38.9	eR	43.8	eR	40.8
		waa	33.0	waa	33.5	waa	30.2	hieR	32.7	dokiQ	33.2
		ooo	27.2	kyaa	27.4	kyaa	26.6	kyaa	31.5	hieR	31.8
	Man	ooo	20.1	eR	21.2	eR	23.4	eR	25.7	gyoQ	31.7
		eR	19.9	ooo	19.9	ooo	19.2	dokiQ	21.9	eR	30.8
		waa	17.1	dokiQ	18.7	dokiQ	18.1	hieR	21.9	dokiQ	29.7
Low	Woman	sowa-sowa	59.3	sowa-sowa	63.5	sowa-sowa	64.7	sowa-sowa	69.4	sowa-sowa	76.4
		zawa-zawa	25.3	zawa-zawa	26.4	zawa-zawa	26.4	zawa-zawa	25.7	moji-moji	26.4
		bata-bata	15.4	jita-bata	17.2	bata-bata	20.0	bata-bata	22.3	zawa-zawa	25.8
	Man	sowa-sowa	39.0	sowa-sowa	45.2	sowa-sowa	51.4	sowa-sowa	59.2	sowa-sowa	66.0
		zawa-zawa	21.3	zawa-zawa	19.4	zawa-zawa	17.2	zawa-zawa	20.3	zawa-zawa	22.1
		bata-bata	14.6	bata-bata	13.3	jita-bata	13.4	bata-bata	18.0	bata-bata	19.7

Table S8. Top three EEEs for fear chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	biku-biku	26.4	biku-biku	30.8	biku-biku	25.9	gyaa	28.9	gyaa	34.5
		gyaa	25.9	gyaa	27.0	gyaa	25.8	biku-biku	25.8	gata-gata	31.7
		gaku-buru	23.5	gata-gata	24.4	gata-gata	23.3	zokuQ	24.2	zokuQ	31.4
	Man	biku-biku	19.2	biku-biku	20.2	biku-biku	19.0	biku-biku	21.9	zokuQ	24.2
		gaku-gaku	16.9	gaku-gaku	16.7	gaku-gaku	18.5	gaku-gaku	18.1	biku-biku	22.2
		gaku-buru	16.8	buru-buru	15.9	buru-buru	17.2	gata-gata	17.1	gata-gata	21.0
Medium	Woman	biku-biku	26.3	biku-biku	28.8	biku-biku	26.4	biku-biku	29.7	zokuQ	31.8
		gaku-buru	19.8	gyaa	23.1	zokuQ	22.4	zokuQ	27.1	gata-gata	30.6
		zokuQ	19.8	buru-buru	22.5	gyaa	20.9	gyaa	26.3	buru-buru	29.8
	Man	biku-biku	19.0	biku-biku	19.0	biku-biku	19.3	biku-biku	23.7	biku-biku	26.8
		zokuQ	16.1	zokuQ	17.0	buru-buru	17.3	zokuQ	18.2	zokuQ	25.7
		gaku-gaku	15.4	gaku-gaku	16.6	gaku-gaku	17.3	zoku-zoku	17.6	gata-gata	22.0
Low	Woman	sowa-sowa	29.7	sowa-sowa	30.4	hara-hara	31.3	hara-hara	37.2	hara-hara	43.0
		doki-doki	24.8	hara-hara	29.5	doki-doki	28.7	doki-doki	29.4	doki-doki	32.2
		hara-hara	24.6	doki-doki	26.2	sowa-sowa	26.0	biku-biku	25.8	biku-biku	28.2
	Man	sowa-sowa	21.4	sowa-sowa	23.0	hara-hara	22.1	hara-hara	27.2	hara-hara	36.6
		doki-doki	17.1	hara-hara	19.9	sowa-sowa	21.3	sowa-sowa	23.6	doki-doki	27.5
		hara-hara	16.6	doki-doki	17.6	doki-doki	19.2	doki-doki	23.0	hiya-hiya	23.9

Table S9. Top three EEEs for anger chosen by different gender-age groups

		20s		30s		40s		50s		60s	
Emotional intensity	Gender	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	ira-ira	44.8	ira-ira	44.4	mukaQ	39.4	mukaQ	46.5	mukaQ	50.6
		iraQ	33.6	iraQ	35.2	muka-muka	37.0	muka-muka	40.8	muka-muka	42.3
		kachiN	22.5	mukaQ	31.9	ira-ira	35.5	ira-ira	33.5	kachiN	33.3
	Man	iraQ	26.0	ira-ira	27.2	mukaQ	26.9	mukaQ	32.6	mukaQ	45.6
		ira-ira	25.4	kachiN	22.4	muka-muka	25.3	muka-muka	31.6	muka-muka	36.0
		kachiN	22.4	muka-muka	21.6	kachiN	23.1	kachiN	24.0	kachiN	27.6
Medium	Woman	ira-ira	45.4	ira-ira	44.1	mukaQ	41.0	mukaQ	45.4	mukaQ	47.4
		iraQ	36.6	iraQ	40.5	muka-muka	37.4	muka-muka	39.7	muka-muka	40.4
		muka-muka	29.1	mukaQ	36.7	iraQ	35.4	iraQ	34.7	kachiN	36.5
	Man	ira-ira	28.6	ira-ira	28.7	mukaQ	29.9	mukaQ	34.8	mukaQ	44.7
		iraQ	25.3	iraQ	26.0	muka-muka	26.1	muka-muka	33.8	muka-muka	38.1
		kachiN	21.8	muka-muka	24.5	kachiN	25.7	kachiN	28.0	kachiN	31.0
Low	Woman	iraQ	33.2	iraQ	37.4	iraQ	36.4	kachiN	41.1	kachiN	40.6
		ira-ira	25.8	kachiN	32.9	kachiN	35.5	iraQ	38.5	iraQ	39.3
		kachiN	24.7	mukaQ	29.4	mukaQ	30.7	mukaQ	34.3	mukaQ	39.0
	Man	iraQ	25.6	iraQ	26.6	iraQ	27.4	iraQ	27.4	kachiN	33.4
		ira-ira	18.2	kachiN	20.7	kachiN	25.5	kachiN	26.1	mukaQ	32.6
		kachiN	17.6	mukaQ	19.4	mukaQ	20.1	mukaQ	25.8	iraQ	30.9

2.2 Relationship between emotional intensity and EEEs: a correspondence analysis

Fig S2. The relationship between the intensity of trust and EEE.
a) The symmetric biplot of EEE by emotional intensity of trust. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of trust.

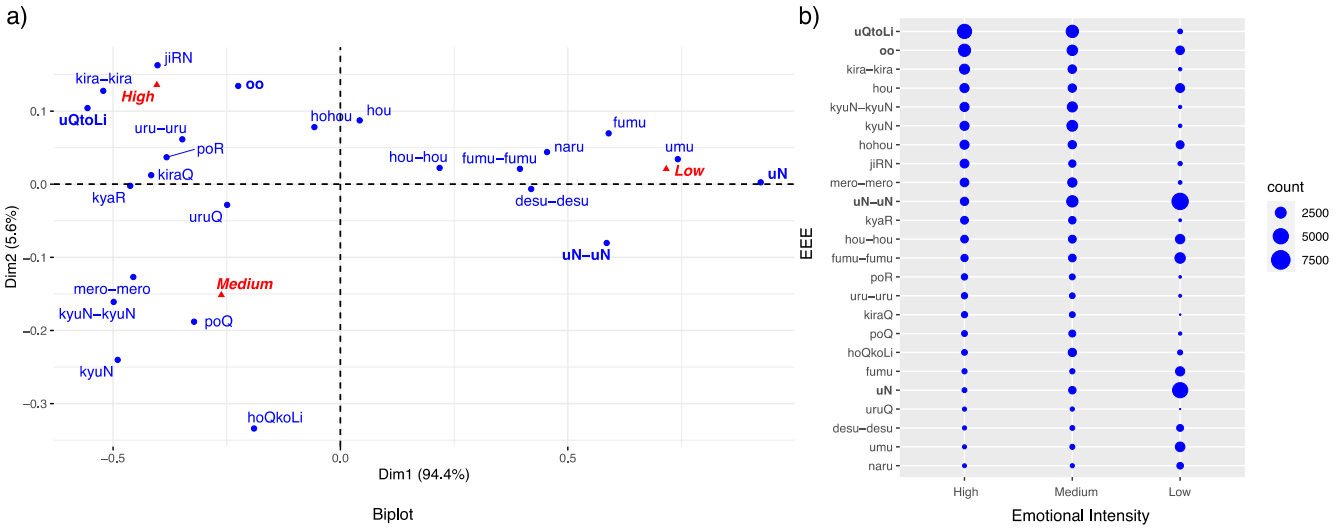


Fig S3. The relationship between the intensity of disgust and EEE.
a) The symmetric biplot of EEE by emotional intensity of disgust. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of disgust.

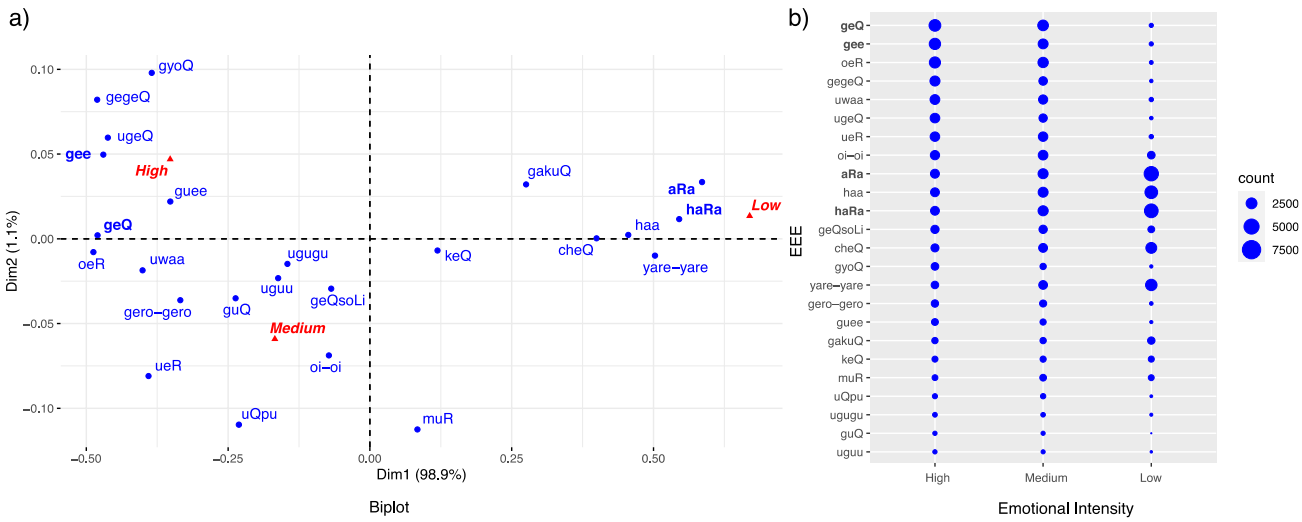


Fig S4. The relationship between the intensity of anticipation and EEE.
a) The symmetric biplot of EEE by emotional intensity of anticipation. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of anticipation.

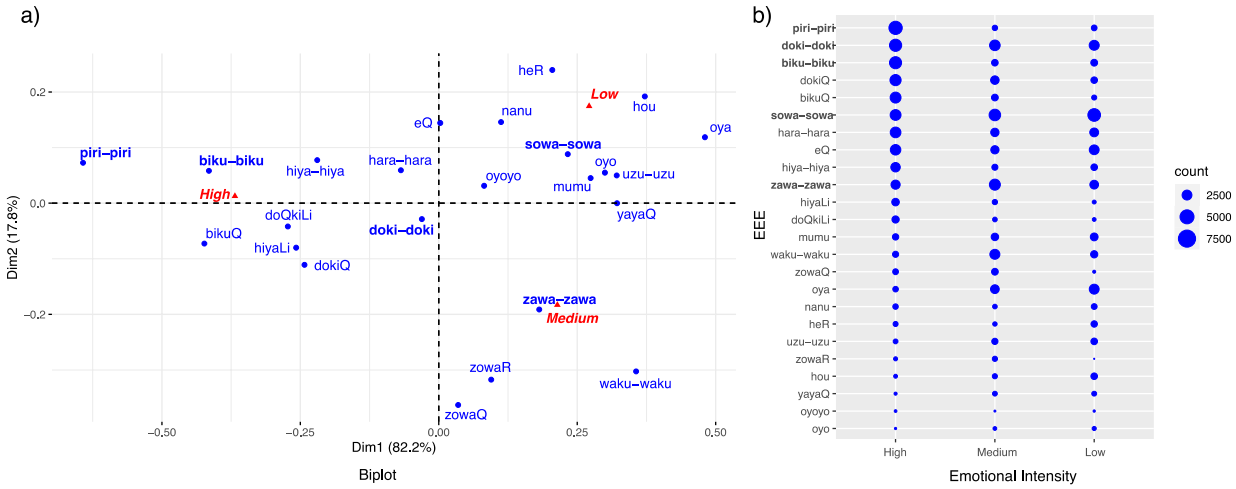


Fig S5. The relationship between the intensity of surprise and EEE.
a) The symmetric biplot of EEE by emotional intensity of surprise. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of surprise.

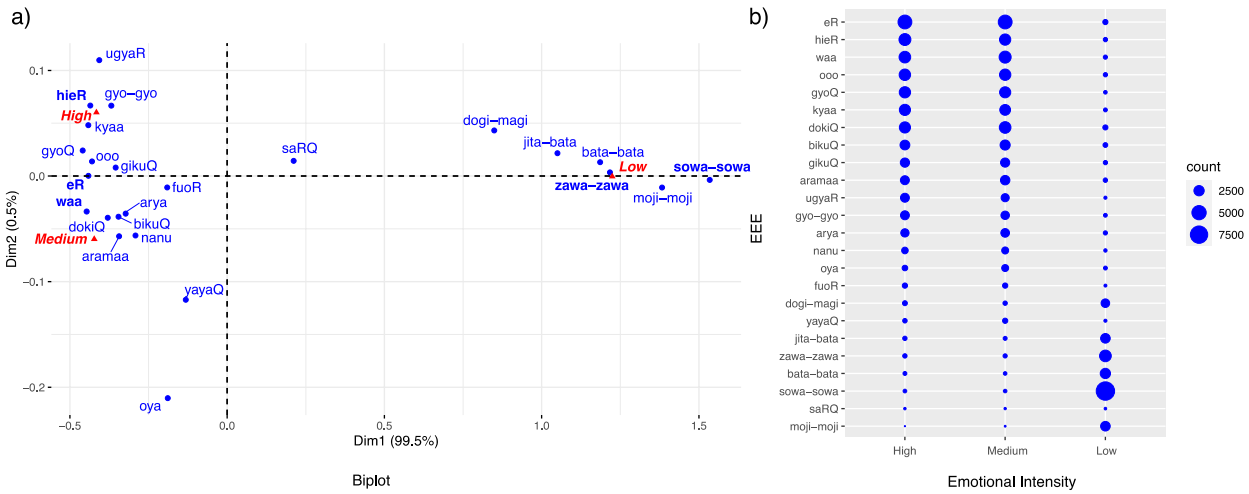


Fig S6. The relationship between the intensity of fear and EEE.

a) The symmetric biplot of EEE by emotional intensity of fear. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of fear.

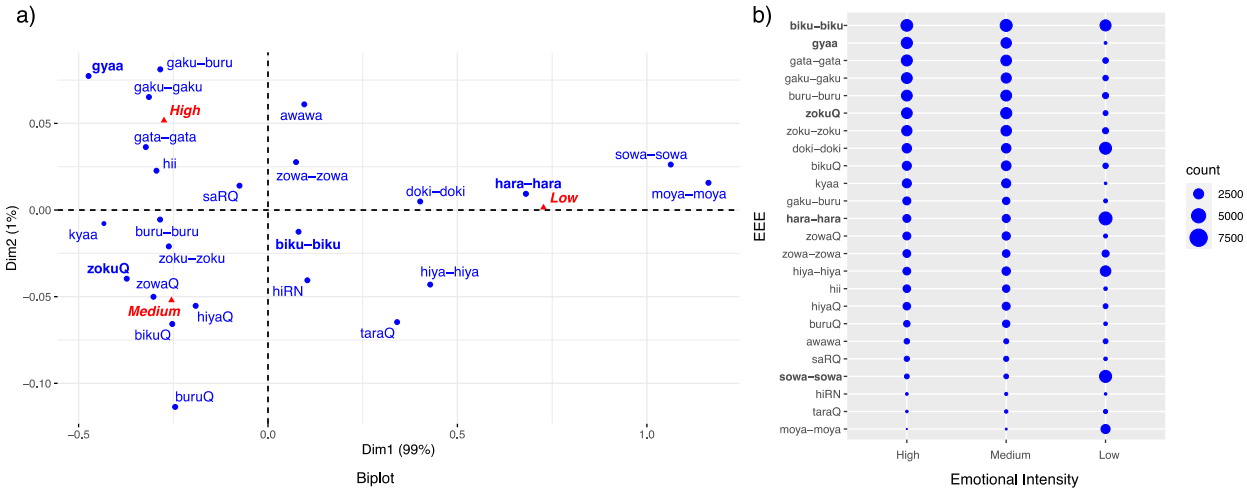
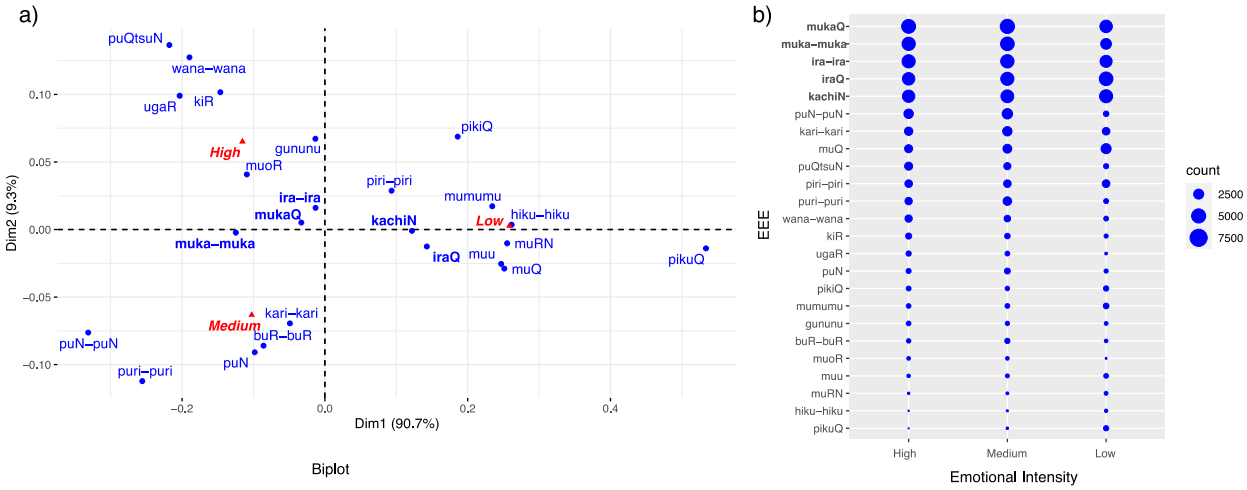


Fig S7. The relationship between the intensity of anger and EEE.

a) The symmetric biplot of EEE by emotional intensity of anger. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of anger.



2.3 Overall differences in size of EEE vocabulary among gender-age groups

A mixed analysis of variance (ANOVA) was used to examine whether there was a gender-age difference in the size of participants' EEE vocabularies. To evaluate the extent of participants' EEE vocabularies, the mean use-frequency of EEEs was calculated for each emotion. For each of the eight categories and three intensities of emotion, participants were required to choose EEEs from a list of 24 EEEs (common within the same emotion category, as shown in Table 1), resulting in a range of average EEE-use frequency from 0 to 24. The mixed ANOVA was conducted using R. Gender (men, women), age (20s, 30s, 40s, 50s, 60s), emotion (joy, sadness, anticipation, surprise, anger, fear, disgust, trust) and their interactions were entered as explanatory variables.

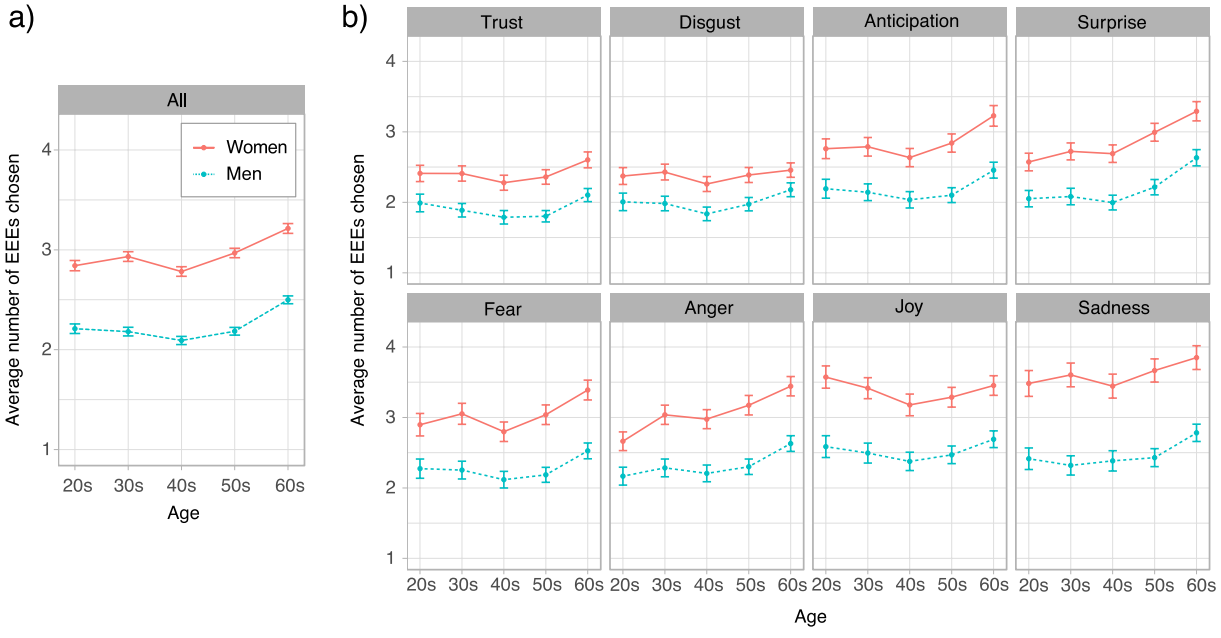
A 5 (Age: 20s, 30s, 40s, 50s, 60s) × 2 (Gender: women, men) × 8 (Emotion: joy, sadness, anticipation, surprise, anger, fear, disgust, trust) mixed ANOVA of mean frequency of EEE use revealed the significant main effects of gender ($F(1, 14311) = 387.180$, $p < 0.001$, $\eta_G^2 = 0.021$), age

($F(4, 14311) = 15.215$, $p < 0.001$, $\eta_G^2 = 0.003$), emotion ($F(7, 100177) = 905.989$, $p < 0.001$, $\eta_G^2 = 0.014$), gender × emotion interaction ($F(7, 100177) = 119.438$, $p < 0.001$, $\eta_G^2 = 0.002$), and age × emotion interaction ($F(28, 100177) = 16.087$, $p < 0.001$, $\eta_G^2 = 0.001$).

Figure S8a shows the mean frequency of EEE use as a function of gender and age. The interaction effect between gender and age was nonsignificant ($F(4, 14311) = 0.512$, $p = 0.727$, $\eta_G^2 = 0.000$). Thus, gender differences were consistent at all ages. Women generally chose more words than men. Although the effect size of age was relatively small, there was a non-linear effect of age on EEE use. Generally, people in their 60s chose more words compared with people in their 20s ($t(14311) = 5.703$, $p < 0.001$), 30s ($t(14311) = 5.257$, $p < 0.001$), 40s ($t(14311) = 7.339$, $p < 0.001$), or 50s ($t(14311) = 4.903$, $p < 0.001$).

However, the gender × emotion and age × emotion interactions indicated that differences in EEE use between emotions differed by gender or age. Figure S8b shows the mean frequency of EEE use as a function of gender and age for each emotion. The overall tendency was common across genders; EEEs for sadness and joy were chosen most often, followed by words for anger, fear, surprise, and anticipation, and words for disgust and trust were chosen the least. However, women chose more words for sadness than for joy ($t(14311) = 8.922$, $p < 0.001$), while men chose more words for joy than for sadness ($t(14311) = 2.778$, $p = 0.011$). As shown in Figure S8b, the effect of age also differed among emotions; people in their 40s chose fewer words for trust, disgust, and joy than people in their 20s, and chose fewer words for disgust and fear compared with people in their 30s. People in their 50s chose more words for surprise than people in their 20s, 30s, or 40s. People in their 60s chose more words for trust, anticipation, and surprise than people of other ages. They also chose more words for joy and disgust than people in their 40s, but did not differ from people in their 20s, 30s, and 50s in those word choices. Although the gender × age × emotion three-way interaction effect was also significant, the effect size was very small ($F(28, 100177) = 3.121$, $p < 0.001$, $\eta_G^2 = 0.000$): a slight gender difference in the effect of age was found only for anger; women in their 20s chose fewer words for anger than people of other ages, while men in their 20s chose words for anger as often as men in their 30s, 40s, and 50s.

Fig S8. Average number of EEEs chosen.
(a) Average number of EEEs chosen as a function of gender and age, and (b) the average number for each emotion. Error bars represent standard error of the mean.



The results indicate that the frequency with which EEEs were used to convey emotions was generally higher among women and the elderly, but the effects of gender and age varied depending on type of emotion. This trend is consistent with a previous report that showed Japanese women used onomatopoeia more frequently in daily conversations than men (Hirata et al., 2012). Such a trend might be reflected in the commonly held beliefs in our society about gender differences in expressing and experiencing emotions: it is generally believed that women are more emotionally responsive and more aware of emotions in themselves and others than men. Research has shown that women scored higher on self-reported emotional tests (e.g., the Level of Emotional Awareness Scale, which measures the ability of an individual to recognize and describe emotions in the self and others) than men (Barrett et al., 2000; Ciarrochi et al., 2003; Ciarrochi et al., 2005; Mankus et al., 2016). Furthermore, studies on age differences in emotional awareness have shown that older participants were good at identifying and representing their emotions (Mankus et al., 2016). Given that the vocabulary of emotion words is linked to emotional awareness (Gross & James, 2002; Mavrou, 2021), Japanese women/older people may have a larger EEE vocabulary with which to express emotions than men/younger people because they generally have higher emotional awareness. Moreover, the gender and age effects also varied depending on the type of emotion. Women had more vocabulary for expressing sadness than for expressing joy, while men had the opposite tendency. People in their 20s had a relatively smaller vocabulary for expressing anger and a larger vocabulary for expressing joy than people of other ages. However, it is unclear whether these differences were caused by emotions that women/men or young people are more likely to actually feel, or by cultural or social norms such as "boys do not cry." To confirm the relationship between the use of EEEs and emotional experience or awareness, further research is needed that combines, for example, lifelogging of behaviors and events.

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Informed consent

We recruited participants from people registered in NTTCom's sampling pool. Those who agreed to the purpose of the research project – called "NTTCom Research" – and to the company's privacy policy were invited to participate. Prior to participating in the survey, we obtained informed consent from all participants through a web form.

Conflict of interest statement

JW and AM are employed by NTT Communication Science Laboratories, Nippon Telegraph and Telephone Corporation as researchers conducting basic scientific research on human emotion and sensory

processing. There are no products in development or on the market that are relevant to this paper. The research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

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Data availability statement

Data are available on request from the corresponding author.

Author contributions statement:

All authors contributed to the study conception and design. AM and JW conceived and designed the survey. AM and YZ analyzed the data. AM, YZ and JW wrote the manuscript. AM and YZ prepared figures and tables. All authors reviewed the manuscript and gave final approval for publication.

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