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

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Abstract: Experience Sampling Method (ESM) is a research procedure for monitoring ever-changing subjective emotions in our daily lives. A typical method asks participants, several times a day, to report and rate their emotions in terms of pre-defined adjective scales (e.g., "2 for sad," and "5 for happy"). When a scale includes many adjectives, rating time is increased for participants. However, when few adjectives are provided, respondents may struggle to find descriptors that truly match their internal state, making it difficult to express the complex nuances of multiple emotions. This paper reports the development of a novel approach to ESM in which participants choose only a single word that intuitively expresses common emotion categories and intensities with minimal demands on their time. To achieve this capability, we conducted a survey with 14,321 Japanese speakers that presented a list of intuitive and embodied emotional expressions such as mimetics (e.g., "thump-thump") and interjections (e.g., "wow") in Japanese, categorized according to the eight primary emotions and three levels of emotional intensity used in the Plutchik model, and asked them to choose the expressions they use in their daily lives. The results showed that the most frequently used expressions were generally consistent irrespective of gender or age, and that people differentiated their use of expressions according to the category and intensity of their emotions. Our findings indicate that it is possible to create a single common list of expressions that can be used by all genders and ages to efficiently and intuitively express nuanced emotions appropriate to their inner states without the person having to think deliberately.

Keywords: Mimetics; ideophones; embodied emotional expressions; experience sampling method; large-scale survey

1. Introduction

Monitoring emotion that changes from moment to moment is crucial for investigating the factors underlying people's daily subjective well-being and happiness (Kahneman et al., 2004; Csikszentmihalyi & Hunter, 2003; Houben et al., 2015). The Experience Sampling Method (ESM) is a research procedure for studying what people feel during their daily lives (Hektner et al., 2007; Scollon et al., 2009). Typically, participants are asked, several times a day over multiple days, to what extent they are feeling a particular emotion, and record their answers using a Likert scale. For example, one question may be: "To what extent did you experience sadness?" with responses ranging from 1, "Not at all," to 7, "An extreme amount." Because there are several types of emotions, this question is repeated for each included emotion. For example, the Positive and Negative Affect Schedule, or PANAS, is a popular scale that measures positive and negative

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affect, but it requires a scale rating for each of 20 different emotion adjectives (Watson et al., 1988). Although scale-rating is an established means of recording emotional states, scales are (1) difficult to respond to intuitively because they require participants to deliberately evaluate their internal states against the scale prepared in advance by the experimenter, and (2) time-consuming for participants to complete because they need to answer multiple questions. Given the need to collect frequent and repetitive recordings from a participant when using ESM, it is important that the method enables intuitive responses without requiring deliberate thinking and that it minimizes psychological loads. Therefore, in the present study, we explored a novel, "easy-to-express" method of recording emotions, in which (1) users can find the appropriate expression for their emotional state more intuitively and quickly than with traditional emotional adjectives, and (2) they can capture the complex nuances and intensity of their emotions by simply selecting the expression from a list. Specifically, we focused on embodied emotional expressions (EEEs; explained in detail in the following paragraph) in Japanese. Analyses of the results of surveys we conducted among Japanese speakers informed our creation of a list of EEEs that represents primary emotions felt by the general population in Japan. By identifying EEEs that resonate with people according to age and gender, Japanese speakers could evaluate and record their own daily emotions more intuitively – in accordance with their 'gut feelings'.

To express complex and minute nuances of emotions in everyday conversations, Japanese speakers often use mimetics (or ideophones) (e.g., "doki-doki" used in a sense similar to the English "thump-thump"), and interjections (e.g., "waR" used in a sense similar to the English "wow") rather than adjectives (e.g., "anticipated," and "surprised" in English). We refer to these iconic expressions depicting emotions as EEEs. While the Japanese language has relatively few adjectives to describe emotional states, it has a large vocabulary of EEEs in the form of mimetics and interjections. EEEs have long been used by Japanese speakers to capture and express a variety of emotions at different intensities with embodied intuitions.

According to a Japanese "Onomatopoeia" dictionary (Japanese mimetics are called "onomatopoeia," Ono, 2007), there are about 4,500 onomatopoeic words in Japanese. These words play an important role in the Japanese language and often appear in genres that involve highly emotional and sensual uses, such as food discourse or music critique (Sasamoto, 2019). Furthermore, Kita (1997) suggests that Japanese onomatopoeia has a unique psychological effect: it evokes vivid "images" of affective experience. It also has been shown that listening to onomatopoeia words as sounds that represent emotional pain, such as "hiri-hiri" or "zuki-zuki," activates the anterior cingulate cortex, which is a region of the brain related to the unpleasantness of pain (Osaka et al., 2004). Additionally, listening to both laughing-related and crying-related onomatopoeia is associated with the activity of the premotor and visual cortices (Osaka & Osaka, 2005; Osaka, 2011). These findings indicate that EEEs are deeply connected to the mental imagery associated with affective experiences.

Ideophones and mimetics form a class of marked words that represent sensory images. They are found in languages throughout the world, from Japan and Korea to Africa, India, Turkey, and South America. In addition to representing sound and movement, there are representations of sensory modalities, including touch and taste, and some include internal feelings and psychological states (Dingemanse, 2012). In sensory research, ideophone and mimetics have been used to capture intuitive and effective inputs for analyzing perceptual space in touch (Fryer et al., 2014; Etzi et al., 2016; Doizaki et al., 2017; Sakamoto & Watanabe 2018) and taste (e.g., Crisinel et al., 2012; Sakamoto & Watanabe, 2015; Ngo et al., 2011). Empirical evidence also contends that a similarity between word form and meaning (i.e., iconicity), represented through mimetics and interjections, may help language users access meaning more quickly and easily through a direct

mapping between form and meaning. For example, research showed improved performance on a reading and lexical decision task when English speakers with aphasia were presented with iconic onomatopoeic words – in contrast with non-iconic control words (Meteyard et al., 2015). Participants can also make faster and more accurate judgments of emotional arousal for words with high acoustic feature and semantic congruency (i.e., iconicity) than for words with low congruency in emotional words (Aryani & Jacobs, 2018).

Therefore, EEEs that have higher iconicity arguably offer advantages in their ability to intuitively convey a participant's inner state with embodied nuances, while reducing the time required and cognitive load imposed on them during data collection. Furthermore, while we focused on Japanese EEEs, EEEs are observed in languages worldwide. English includes a few EEEs, such as "oops," "ooh," and "boo-hoo." EEEs are especially prevalent in some Asian (e.g., Japanese and Korean) and African (e.g., Somali) languages (Akita & Dingemanse, 2019). For example, with Korean sound symbolic words, the sound and feel of a throbbing heart can be expressed as "du-geun du-geun," of crying as "eong-eong," and of smiling as "sing-geul beong-geul." Thus, the approach used in this study could also be applied to other Indo-European and Asian languages, even though the list of EEEs developed in this study is specific to Japanese speakers.

Although the affective and embodied nature of EEEs might make them useful for evaluating and expressing internal emotions, to date, they have rarely been put to practical use in research that uses the ESM for assessing emotions. To use the ESM effectively, moreover, it is first necessary to identify which EEEs are used most frequently in the participants' language to express a wide variety of emotions in daily life. In this study, we conducted surveys to create a list of emotion expressions suitable for use in ESM surveys. The EEEs enable more efficient capturing (i.e., more intuitively and with less effort for the user) of a similar range of emotion categories and intensities of traditionally used emotion expressions.

Previous studies of Japanese speakers have shown that the type and use frequency of sensory and emotional mimetics can depend on age (Aiba et al., 2016) and gender (Hirata et al., 2012), although there were no observed differences in the frequency of word use between major regions in Japan (Hirata et al., 2012; Takamaru et al., 2015). If the EEEs frequently used to express emotions differ by gender and age, then gender- and age-specific lists of EEEs need to be created; if they are common, then a single list for use in ESM could be applied to many people.

Therefore, in Study 1, we first conducted a large-scale survey with 14,321 native Japanese speakers to examine the EEEs that people most frequently use to express their emotions, by gender and age, and to determine how people use EEEs in different ways depending on the emotional intensity. In Study 2, we focused on the EEEs frequently selected in Study 1, and conducted a small additional survey to identify the EEEs that best represent each emotional category/intensity. Based on the results of the two surveys, we created a list of EEEs that Japanese speakers commonly use to express emotions. Using this list of EEEs for ESM surveys, users can quickly capture the nuances of their emotions by simply selecting an EEE from the list that matches the emotion they are feeling at the time when they receive a reminder to respond.

2. Study 1

2.1 Materials and methods

2.1.1 Participants

A total of 14,321 native Japanese speakers took part in the survey. Participants' ages ranged from 20 to 69 years. The online survey was conducted by NTTCom Online Marketing Solutions

Corporation (Tokyo, Japan). We recruited participants from NTTCom's registered 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. Participants received compensation (points that can be converted into electronic money) after completing all questionnaire items. The gender and age distribution of participants is summarized in Table 1.

Table 1. Percentage of participants by gender and age

Age (years)	Men (N = 7,091)	Women (N = 7,230)
20 to 29	21.31%	22.04%
30 to 39	22.31%	20.47%
40 to 49	19.58%	18.62%
50 to 59	18.51%	18.87%
60 to 69	18.29%	20.01%

2.1.2 Procedure

In Study 1, we categorized EEEs according to Plutchik's (2001) model of emotion that combines features describing multiple emotion categories (e.g., a categorical model of primary emotions; Ekman, 1992) with features that can describe the intensity of emotions (e.g., a dimensional model of emotions; Russell, 1980). Plutchik's model consists of eight primary emotions (i.e., joy, sadness, anticipation, surprise, anger, fear, disgust, and trust) with three levels of intensity (i.e., high, medium, and low emotional intensity) for each. Participants were asked to choose words that they frequently use in daily life from the lists of EEEs that were created separately for each of the eight emotional categories.

In the survey, 24 separate candidate EEEs were presented as options for each of eight emotional categories, from which participants could choose (see Table 2 for full list of EEEs). The list of EEEs was created in two steps. First, we made a list of 6,348 two-syllable expressions that was composed of all possible combinations of the first and second syllables (e.g., /gaku/, /gan/, /doki/). Two experts (including one of the authors) in psychology and user experience design listed all the sound-symbolic words conveying mental or physical states that begin with one of the two-syllable expressions (macron and double consonant could be added, e.g., /gaQkuLi/, /gaRN/, /doQkiLi/). If no corresponding word was found starting with a two-syllable expression, the field for that syllable combination was left blank. In total, 526 EEEs were included in the list. In the second step, three native Japanese speakers, including one expert in psychology (i.e., one of the authors), chose 24 EEEs from the list created in the first step that they deemed suitable and sufficient for fully expressing each of the eight primary emotions in the Plutchik model (if they found another suitable EEE, it was added in the second step and a separate list of 24 EEEs was created for each emotional category).

The final list of EEEs used in the survey is shown in Table 2. In the survey, participants were asked to choose the EEEs from the lists that most closely reflected expressions that they use in daily life; this was done for each of the eight emotions at three levels of emotional intensity (i.e., high intensity, medium intensity, and low intensity). Participants were asked to choose multiple EEEs if they felt that more than one EEE was appropriate to express a particular emotion, and each EEE could be chosen repeatedly at the three levels of emotional intensity. See Supplementary Table S1 for the items in the online questionnaire.

Table 2. Full list of embodied emotional expressions (EEEs) used in the survey

Joy	Sadness	Anticipation	Surprise	Anger	Fear	Disgust	Trust
uhyoR (うひょー)	uwaRN (うわーん)	piri-piri* (ぴりぴり)	kyaR* (きゃー)	wana-wana (わなわな)	gyaa (ぎゃあ)	oeR (おえー)	uQtoLi (うっとり)
waRi (わーい)	kusuN (くすん)	biku-biku* (びくびく)	hieR (ひえー)	hiku-hiku (ひくひく)	hii (ひい)	ueR (うえー)	kyuN (きゅん)
yoQshaa (よっしゃぁ)	gusuQ (ぐすっ)	hiya-hiya* (ひやひや)	fuoR (ふぉー)	puQtsuN (ぷっつん)	hiRN* (ひーん)	guee (ぐええ)	uru-uru (うるうる)
gufufu (ぐふふ)	bieR (びええ)	hara-hara* (はらはら)	ooo (おおお)	pikiQ (ぴきっ)	gata-gata (がたがた)	gyoQ* (ぎょっ)	desu-desu (ですです)
ueRi (うぇーい)	hiRN* (ひーん)	hiyaLi (ひやり)	gyoQ* (ぎょっ)	mukaQ (むかっ)	buru-buru (ぶるぶる)	gero-gero (げろげろ)	kira-kira (きらきら)
uhoQ (うほっ)	uruQ (うるっ)	dokiQ* (どきっ)	arya (ありゃ)	puN (ぷん)	hiya-hiya* (ひやひや)	uQpu (うっぷ)	kyaR* (きゃー)
uhihi (うひひ)	shoNboLi (しょんぼり)	bikuQ* (びくっ)	ugyaR (うぎゃー)	muoR (むおー)	hara-hara* (はらはら)	gegeQ (げげっ)	kyuN-kyuN (きゅんきゅん)
uhyahya (うひゃひゃ)	gaRN (がーん)	zowaR (ぞわー)	gyo-gyo (ぎょぎょ)	ugaR (うがー)	gaku-gaku (がくがく)	ugeQ (うげっ)	mero-mero (めろめろ)
ufufu (うふふ)	shiku-shiku (しくしく)	doki-doki* (どきどき)	eR (えー)	piri-piri* (ぴりぴり)	zowa-zowa* (ぞわぞわ)	uwaa (うわぁ)	kiraQ (きらっ)
ruN-ruN (るんるん)	eRN (えーん)	uzu-uzu (うずうず)	bikuQ* (びくっ)	puN-puN (ぷんぷん)	awawa (あわわ)	uguu (うぐぅ)	uruQ (うるっ)
niko-niko (にこにこ)	meso-meso (めそめそ)	waku-waku (わくわく)	aramaa (あらまあ)	muka-muka (むかむか)	saRQ (さーっ)	ugugu (うぐぐ)	hoQkoLi* (ほっこり)
nishishi (にしし)	uru-uru (うるうる)	sowa-sowa* (そわそわ)	oya* (おや)	pikuQ (ぴくっ)	gaku-buru (がくぶる)	gee (げぇ)	jiRN (じーん)
fufufu (ふふふ)	guzu-guzu (ぐずぐず)	zawa-zawa* (ざわざわ)	nanu* (なぬ)	puri-puri (ぷりぷり)	zowaQ* (ぞわっ)	muR (むー)	oo (おお)
kukuku (くくく)	kusuN-kusuN (くすんくすん)	zowaQ* (ぞわっ)	yayaQ* (ややっ)	kiR (きいい)	kyaa (きゃあ)	keQ (けっ)	hou* (ほう)
nihi (にひ)	gusuN (ぐすん)	doQkiLi (どっきり)	waa (わあ)	buR-buR (ぶーぶー)	zoku-zoku (ぞくぞく)	haRa (はーあ)	poR (ぽー)
ehehe (えへへ)	zuRN (ずーん)	eQ (えっ)	dokiQ* (どきっ)	kachiN (かちん)	zokuQ (ぞくっ)	geQsoLi (げっそり)	poQ (ぽっ)
hoQkoLi* (ほっこり)	shuN (しゅん)	oyo (およ)	sowa-sowa* (そわそわ)	ira-ira (いらいら)	taraQ (たらっ)	geQ (げっ)	uN (うん)
fuwa-fuwa (ふわふわ)	chiRN (ちーん)	oyoyo (およよ)	moji-moji (もじもじ)	mumumu (むむむ)	buruQ (ぶるっ)	guQ (ぐっ)	umu (うむ)
hoku-hoku (ほくほく)	shoboN (しょぼん)	mumu (むむ)	zawa-zawa* (ざわざわ)	gununu (ぐぬぬ)	moya-moya (もやもや)	cheQ (ちぇっ)	naru (なる)
nuku-nuku (ぬくぬく)	uuu (ううう)	hou* (ほう)	bata-bata (ばたばた)	muQ (むっ)	biku-biku* (びくびく)	yare-yare (やれやれ)	uN-uN (うんうん)
nikoQ (にこっ)	hena-hena (へなへな)	nanu* (なぬ)	gikuQ (ぎくっ)	kari-kari (かりかり)	bikuQ* (びくっ)	oi-oi (おいおい)	fumu-fumu (ふむふむ)
funyaRN (ふにゃーん)	gakuQ* (がくっ)	oya* (おや)	saRQ (さーっ)	iraQ (いらっ)	sowa-sowa* (そわそわ)	aRa (あーあ)	fumu (ふむ)
howaRN (ほわーん)	gaQkuLi (がっくり)	yayaQ* (ややっ)	jita-bata (じたばた)	muRN (むーん)	doki-doki* (どきどき)	gakuQ* (がくっ)	hohou (ほほぅ)
hono-bono (ほのぼの)	shiNmiLi (しんみり)	heR (へー)	dogi-magi (どぎまぎ)	muu (むう)	hiyaQ (ひやっ)	haa (はぁ)	hou-hou (ほうほう)

Note. The EEEs with an asterisk were added to the choices across multiple categories. All EEEs in this paper were written according to the Japanese ordering of kana. Geminate consonants are represented as /Q/, nasal consonants are represented as /N/, and long vowels are represented as /R/.

2.2 Data analysis

2.2.1 Similarity of EEE use within gender-age groups

To compare the patterns of EEE use across different gender-age groups, we counted the most frequently used EEEs for each emotion in each gender-age group. The three most frequently used EEEs chosen to describe each of the eight emotions at high, medium, and low intensities are summarized in tables (see Tables 3 and 4, and Supplementary Tables S4–S9)

2.2.2 Relationship between emotional intensity and EEEs: a correspondence analysis

To determine the patterns of participants' EEE use when describing emotional states at different intensities, we conducted a correspondence analysis, which produced a visualization of the relationships between words in the form of a multi-dimensional plot (Aitchison & Greenacre, 2002; Gabriel, 2002; Glynn, 2014; Greenacre, 2016). Correspondence analysis takes the frequency of co-occurring features among certain words, converts them to distances, and then plots them to reveal how close or far apart the words are. Here, conceptual closeness is expressed on the basis of the frequency with which each word was chosen as representing three emotional intensities: low, medium, and high.

Correspondence analysis generally constructs a two-dimensional map using the two dimensions with the highest inertia. Thus, we also used two-dimensional maps to visualize the relationship between the three emotional intensities and the EEEs. When the three emotional intensities are far apart on the two-dimensional map, it suggests that the EEEs are used differently for each emotional intensity, and when they are close, it suggests that the EEEs are not used differently. EEEs that are close in terms of intensity are placed close together on the map. Note that the two-dimensional maps are constructed for each emotional category, and the balance of inertia of the two-dimensional axes is different in each (for a more detailed explanation of correspondence analysis, see Supplementary materials).

2.2.3 Differences in vocabulary size according to type and intensity of the emotion

To examine whether the size of EEE vocabulary changes with the intensity of emotional expression, we conducted a 3 (Intensity: low, medium, high) × 8 (Emotion: joy, sadness, anticipation, surprise, anger, fear, disgust, trust) mixed ANOVA on mean frequency of EEE use.

2.3 Results and discussion

2.3.1 Similarity of EEEs within gender-age groups

To find the most used EEEs for each emotional category at the three levels of emotional intensity among each gender-age group, the three most frequently used EEEs for describing each emotion were counted and summarized. Tables 3 and 4 show the results for joy and sadness, respectively. As shown in the tables, frequently used EEEs did not differ much by age or gender. Although the rankings were different for men and women, the top three EEEs for joy at low intensity were common across all gender and age groups (women: 1st: "hoQkoLi," 2nd: "hono-bono," 3rd: "howaRN"; men: 1st: "hono-bono," 2nd: "hoQkoLi," 3rd: "howaRN"). The words used to describe the emotion of joy at high and medium intensities were almost the same, while those for low intensity joy were very different from the high- and medium-intensity descriptors among all gender-age groups. Specifically, "waRi" was frequently used by all gender-age groups, and "yoQshaa" was also frequently chosen by all genders-age groups except women in their 60s. For sadness, "gaRN" or "gaQkuLi" were frequently used among all gender-age groups, as an EEE for high emotional intensity. The words used to describe the emotion of sadness at medium and

low intensities were similar: the EEE, "shoNboLi," was frequently used among all gender-age groups.

With respect to the other six emotions, some people in their 20s and 60s tended to differ slightly from other age groups; nevertheless, commonly used EEEs were identified across gender-age groups (see Supplementary Tables S4–S9). In general, frequently used EEEs were fairly consistent across gender-age groups.

Table 3. Top three EEEs for joy chosen by different gender-age groups

Emotional intensity	Gender	20s		30s		40s		50s		60s	
		EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)	EEE	Ratio (%)
High	Woman	waRi	66.5	waRi	65.5	waRi	62.9	waRi	64.8	waRi	57.8
		yoQshaa	47.7	yoQshaa	41.9	yoQshaa	38.6	yoQshaa	38.9	niko-niko	39.4
		ueRi	38.3	niko-niko	31.9	niko-niko	29.1	niko-niko	34.0	ruN-ruN	36.2
	Man	yoQshaa	47.9	yoQshaa	47.9	yoQshaa	48.2	yoQshaa	51.9	yoQshaa	53.5
		waRi	31.0	waRi	31.3	waRi	27.7	waRi	31.3	waRi	32.9
		ueRi	28.0	ueRi	18.7	niko-niko	20.8	niko-niko	27.0	niko-niko	30.4
Medium	Woman	waRi	66.0	waRi	67.2	waRi	65.9	waRi	66.8	waRi	57.8
		yoQshaa	42.6	yoQshaa	37.0	yoQshaa	31.3	niko-niko	34.6	niko-niko	45.8
		ueRi	32.3	niko-niko	29.9	niko-niko	28.0	yoQshaa	31.1	ruN-ruN	34.2
	Man	yoQshaa	44.0	yoQshaa	41.0	yoQshaa	38.3	yoQshaa	40.3	niko-niko	39.5
		waRi	32.0	waRi	34.3	waRi	33.1	waRi	35.3	yoQshaa	37.1
		ueRi	21.6	niko-niko	19.5	niko-niko	24.1	niko-niko	28.9	waRi	36.0
Low	Woman	hoQkoLi	45.7	hoQkoLi	47.5	hoQkoLi	48.6	hoQkoLi	51.2	hoQkoLi	57.0
		hono-bono	39.0	hono-bono	41.0	hono-bono	45.3	hono-bono	48.1	hono-bono	51.1
		howaRN	24.8	howaRN	26.5	howaRN	24.2	howaRN	25.4	howaRN	27.1
	Man	hono-bono	29.2	hono-bono	32.4	hono-bono	33.9	hono-bono	38.3	hono-bono	43.8
		hoQkoLi	28.6	hoQkoLi	28.7	hoQkoLi	33.4	hoQkoLi	34.2	hoQkoLi	38.5
		howaRN	16.3	howaRN	14.6	nuku-nuku	15.5	howaRN	15.0	howaRN	17.4

Note. The top three most frequently chosen EEEs and the percentage of participants who chose these EEEs as a function of gender and age.

Table 4. Top three EEEs for sadness 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	gaRN	42.1	gaRN	44.6	gaQkuLi	44.6	gaQkuLi	49.0	gaQkuLi	48.6
		shoNboLi	32.4	gaQkuLi	39.5	gaRN	41.3	shoNboLi	38.7	shoNboLi	42.2
		uwaRN	31.9	shoNboLi	34.0	shoNboLi	37.7	gaRN	38.6	shoboN	36.8
	Man	gaQkuLi	27.9	gaQkuLi	29.6	gaQkuLi	35.8	gaQkuLi	40.7	gaQkuLi	48.9
		gaRN	25.6	gaRN	24.4	shoNboLi	24.9	gaRN	27.9	shoNboLi	35.7
		shoNboLi	20.4	shoNboLi	20.7	gaRN	24.8	shoNboLi	26.7	shoboN	31.2
Medium	Woman	shoboN	30.1	shoNboLi	34.1	shoNboLi	30.9	shoNboLi	33.1	shiku-shiku	38.0
		shoNboLi	29.7	gaRN	30.5	shiku-shiku	29.9	shiku-shiku	32.6	shoNboLi	36.5
		gaRN	26.5	shiku-shiku	29.0	gaQkuLi	27.6	gaQkuLi	30.7	meso-meso	32.2
	Man	gaQkuLi	22.0	gaQkuLi	21.4	gaQkuLi	24.8	gaQkuLi	27.0	shoNboLi	33.4
		shoNboLi	18.6	shoNboLi	19.5	shoNboLi	20.7	shoNboLi	23.9	gaQkuLi	28.4
		gaRN	18.0	gaRN	18.4	shiku-shiku	17.2	shiku-shiku	19.9	shoboN	26.3
Low	Woman	shoNboLi	29.6	shoNboLi	33.0	shoNboLi	38.6	shoNboLi	41.0	shoNboLi	48.2
		shoboN	27.5	shoboN	29.9	shoboN	32.8	shoboN	37.9	shoboN	44.0
		chiRN	24.8	gaQkuLi	26.0	gaQkuLi	29.4	gaQkuLi	31.3	gaQkuLi	33.8
	Man	shoNboLi	20.2	shoNboLi	23.1	shoNboLi	26.9	shoNboLi	33.8	shoNboLi	41.4
		gaQkuLi	19.7	shoboN	18.4	gaQkuLi	25.2	shoboN	26.8	shoboN	36.9
		shoboN	19.6	gaQkuLi	18.4	shoboN	21.6	gaQkuLi	26.3	gaQkuLi	29.0

Note. The top three most frequently chosen EEEs and the percentage of participants who chose these EEEs as a function of gender and age.

2.3.2 Relationship between emotional intensity and EEEs: a correspondence analysis

To provide a visual inspection of the associations among EEEs and emotional intensities, the symmetric biplots of EEE by emotional intensity are shown for the emotions of joy and sadness in Figures 1 and 2, respectively (see Supplementary Figures S2–S7 for the biplots of the other six emotions). In the biplot, frequently used EEE are shown in bold. Clearly, in both the joy and sadness biplots, the first dimension was very important because it accounted for most of the total variance (joy: 97.4%, sadness: 85.3%). In other words, the differences in intensity explained most of the relationships. As shown in Figures 1a and 2a, the differences between "high intensity" and "low intensity" and between "medium intensity" and "low intensity" were both large. It should be noted, however, that while the ordering of emotional intensities along the first dimension was "medium," "high," and "low," the difference between the first two intensities was quite small.

In the biplot for joy, among the most frequently used EEEs (shown in bold in Fig. 1a), "hoQkoLi" and "hono-bono" are in close proximity; these were frequently used to express low-intensity joy. By contrast, "yoQshaa" and "waRi" are located on the far left, and were often used to indicate medium- to high-intensity joy. In the biplot for sadness, "shoNboLi," "shoboN," and "shuN" are in close proximity, and were frequently used to express low-intensity sadness; "gaRN," "gaQkuLi," and "gakuQ" were often used to indicate high-intensity sadness. As shown in Figures 1b and 2b, frequently used words were somewhat common between high and medium

intensities, while those for low intensity emotions showed different patterns from their high- and medium-intensity counterparts. Therefore, it may be difficult to distinguish between high- and medium-intensity emotional experiences of joy and sadness using EEEs; similar patterns were observed for surprise, anger, fear, disgust, and trust (see Supplementary Figures S2–S3, S5–S7). The emotional intensity boundaries for "anticipation," however, differed from the other emotions: there was ambiguity evident between medium and low intensities, and clarity between high and low-medium intensities (see Supplementary Figure S4).

Fig 1. The relationship between the intensity of joy and EEE.
a) The symmetric biplot of EEE by emotional intensity of joy. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of joy is represented by the size of the blue circle.
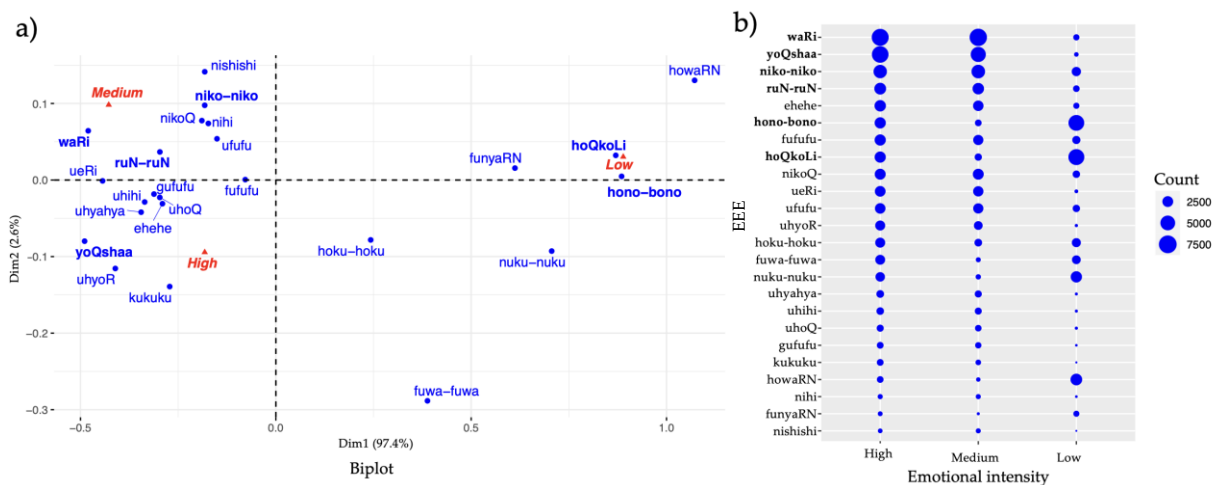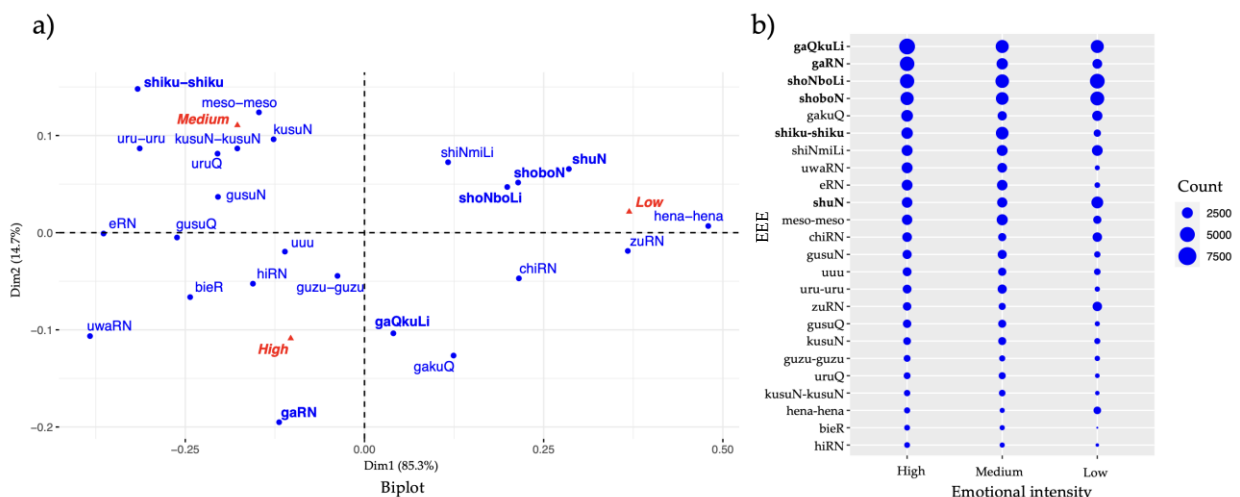

Fig 2. The relationship between the intensity of sadness and EEE.
a) The symmetric biplot of EEE by emotional intensity of sadness. Frequently used EEEs across all emotional intensities are shown in bold. b) Frequency of EEE chosen for each intensity of sadness is represented by the size of the blue circle.


2.3.3 Differences in EEE vocabulary size according to type and intensity of the emotion

In our analysis, we also sought to determine whether the size of an EEE vocabulary changes with the intensity of emotional expression. We analyzed the differences in the use-frequency of EEEs for each emotion according to the intensity of the emotion. A 3 (Intensity: low, medium, high) ×

8 (Emotion: joy, sadness, anticipation, surprise, anger, fear, disgust, trust) mixed ANOVA for the mean of EEE use-frequency showed significant main effects of emotion ($F(7, 100240) = 902.048$, $p < 0.001$, $\eta_{G^2} = 0.011$), intensity ($F(2, 28640) = 4309.178$, $p < 0.001$, $\eta_{G^2} = 0.014$), and emotion x intensity interaction ($F(14, 200480) = 564.831$, $p < 0.001$, $\eta_{G^2} = 0.005$). In general, the higher the intensity of the emotion, the higher the use-frequency of the chosen EEE (low vs. medium: $t(14320) = 65.115$, $p < 0.001$, medium vs. high: $t(14320) = 31.913$). The emotion x intensity interaction, however, indicated that this tendency varied by emotion. For size of EEE vocabularies for joy, sadness, disgust, and anticipation, we found a typical trend, such that the higher the intensity of the emotion, the greater the size of EEE vocabulary. For the EEE vocabulary for surprise, there was a larger vocabulary for medium and high intensities than for low intensity, but the size of vocabulary for the medium and high intensities was similar. By contrast for anger, fear, and trust, the order of EEE vocabulary size was reversed between medium and high intensities: there was a larger vocabulary for medium intensity than for high intensity, although the difference was very small (low< high<medium; see Fig. 3).

As shown in Figure 3, the overall number of EEEs chosen for trust and disgust was low at any intensity, averaging about two for each, while for anticipation, surprise, fear, and anger, the number was about two at low intensity for each emotion and about three at medium or high intensity for each. For expressions of joy and sadness, the greater the intensity of the emotion, the more variation there was; thus, the more options there are, the easier it would be for users to choose expressions that best match their inner states when participating in ESM studies. Studies on the duration of various emotions have reported that sadness tends to last the longest (sometimes several days) and joy tends to last a relatively long time (several hours to more than a day), compared with emotions such as disgust, fear, and surprise (ranging from a few minutes to two hours) (Scherer & Wallbott, 1994; Verduyn et al., 2009; Verduyn & Lavrijsen, 2015). Although only speculation, the results of our study, in which sadness had the largest vocabulary, followed by joy, may imply that there are many EEEs to express the nuances of emotions that change over a long period of time.

Fig 3. Average number of EEEs chosen as a function of emotional intensity.

Error bars represent standard error of the mean.
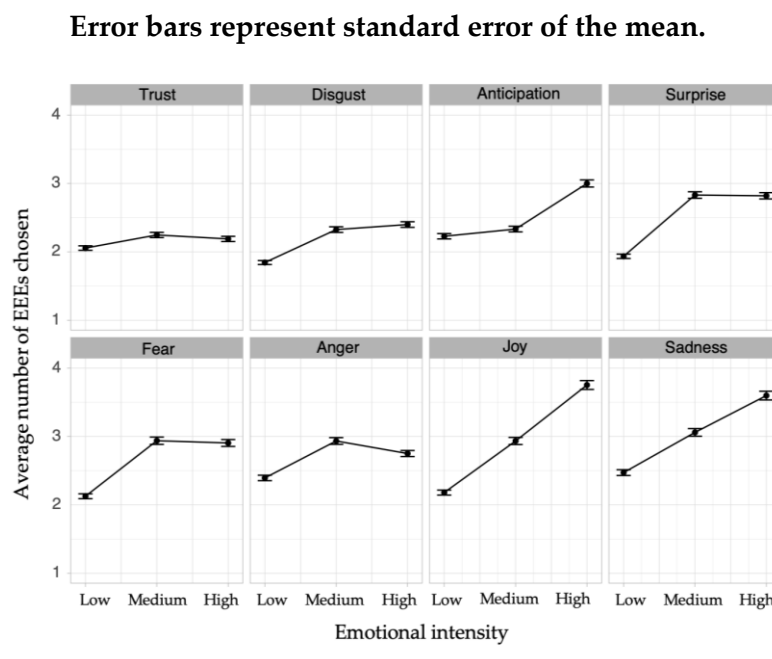
The results of Study 1 showed that the EEEs most commonly used to express emotions were similar by gender and age. Therefore, if participants are accustomed to using EEEs, it is reasonable to adopt a common list of emotion related EEEs for use in ESM studies. The results of the correspondence analysis showed that the use of EEEs by emotional intensity was not clearly split between the three levels (high, medium, and low) but medium-high and low-medium, intensities were common, depending on the emotional categories. With regard to EEE vocabulary size, we found that the relationship between intensity and vocabulary size differed across emotions, with some emotions, such as joy, sadness, disgust, and anticipation, having more EEE vocabulary at higher intensities, and others, such as anger, fear, and trust, having less vocabulary at higher intensities than emotions at medium intensities.

Study 1 allowed us to determine the consistency of EEE use for Japanese speakers across gender and age, and the use of EEEs by emotional intensity. However, it remains difficult to conclude whether EEEs can clearly distinguish respondents' emotional categories because separate lists of EEEs were used for each emotional category. Therefore, we conducted an additional small-scale survey as Study 2. The survey used an identical list of EEEs for all emotional categories, consisting of EEEs that had been shown to be frequently used to express emotions in Study 1.

3. Study 2

3.1 Materials and methods

3.1.1 Participants

Thirty-five native Japanese speakers (15 women and 19 men; 1 person who did not indicate gender) took part in the online survey. Participants' ages ranged from 21 to 57 years (mean = 30.69 years, SD = 9.51). Participants were informed about the survey in advance, and those who agreed to the explanations participated in the survey.

Table 5. The list of 44 EEEs used in Study 2

1. aRa	2. ira-ira	3. iraQ	4. uQtoLi	5. uN-uN	6. eR
7. oeR	8. oo	9. oya	10. gaRN	11. gata-gata	12. kachiN
13. gaQkuLi	14. gyaa	15. kyuN	16. kira-kira	17. gee	18. geQ
19. zawa-zawa	20. shiku-shiku	21. shoboN	22. shoNboLi	23. zokuQ	24. sowa-sowa
25. dokiQ	26. doki-doki	27. niko-niko	28. haa	29. haRa	30. bata-bata
31. hara-hara	32. hieR	33. biku-biku	34. piri-piri	35. fumu-fumu	36. buru-buru
37. hoQkoLi	38. hono-bono	39. howaRN	40. mukaQ	41. muka-muka	42. yoQshaa
43. waa	44. waRi				

Note. A list sorted from left to right in Japanese syllable order was presented as options.

3.1.2 Procedure

A list of 44 candidate EEEs were presented as options for all emotional categories and intensities from which participants could choose. The list of EEEs was created by extracting the three most selected words for eight emotional categories and three emotional intensities (3 x 8 x 3 = 72 words in total) and then eliminating duplicates, giving 44 words in total (Table 5). Respondents were

asked to choose the EEEs from the list in Table 5 that they thought would fit as expressions of each emotional state. Specifically, respondents were asked to choose the EEEs they felt could express the emotional state represented by each cell for the eight emotional categories and three emotional intensities shown in Table 6 (multiple choice allowed).

Table 6. Descriptions of each emotional category and intensity

	Trust	**Disgust**	**Anticipation**	**Surprise**
High	You have longing and respect	You have a strong disgust	You are wary of something	You are very surprised
Medium	You have a positive feeling	You are uncomfortable	You have anticipation	You are surprised
Low	You are accepting	You are bored	You have something on your mind	You are distracted
	Fear	**Anger**	**Joy**	**Sadness**
High	You are so scared	You are indignant	You are ecstatic and feel strong joy	You are mourning
Medium	You feel afraid	You get angry	You feel joy	You are sad
Low	You feel anxious	You are annoyed	Your heart is calm	You are a little depressed

Note. The respondents were asked to choose from the list in Table 5 the EEEs that they felt could express the emotional state represented by each cell (multiple selections were allowed).

3.2 Results and discussion

The most frequently chosen EEEs and the percentages of participants who chose those EEEs are shown in Table 7. Most of the EEEs were placed in the emotional category that had been assumed in Study 1, although there were some exceptions, e.g., "niko-niko" was classified in the joy category in Study 1 but chosen as part of the trust category in Study 2, and "gyaa" was classified in the fear category first but placed in the surprise category here. Many EEEs were placed in only one specific emotional category, but a few (i.e., "zawa-zawa" and "sowa-sowa") were frequently chosen across multiple categories, suggesting that EEEs can be useful in determining respondents' emotional categories.

A possible reason for EEEs being placed in different emotional categories in Studies 1 and 2 is the similarity or relatedness between emotions. Plutchik's model of emotion places surprise and fear near one another, and it is assumed that the two emotions are sometimes mixed (Plutchik, 2001). People are surprised when something happens that they did not expect, and depending on the nature of the event, they may be enthused or fearful. Thus, it is understandable that "gyaa" was chosen most frequently as an expression of strong fear in Study 1, and of strong surprise in Study 2. Similarly, "niko-niko" was classified as joy in Study 1 and chosen as an

expression of trust in study 2 – joy and trust are similar positive emotions, appearing next to each other in Plutchik's model.

It should also be noted that the EEEs most likely to be selected to express strong anger were selected at a low rate of approximately 30%. This result may be related to the limited vocabulary for high-intensity anger in Study 1 (see Fig. 3) – it is difficult to express extreme anger with EEEs. However, given that the anger felt on a daily basis is mostly moderate, such as irritation, this would not be a critical issue when using EEEs to record people's daily emotions in ESM.

Consistent with the findings of Study 1, frequently used words were common between high and medium intensities for the expressions of both anger and sadness. However, considering the most commonly chosen EEEs were different for medium-high and low intensities, it would be acceptable to use EEEs to describe at least two levels of intensity (i.e., higher vs. lower). Whether two levels are a sufficient description of emotional intensity will depend on the purpose of the research. For example, in a study to capture acute emotional changes at festivals or in emergencies – where large changes in emotional intensity are expected – it would be appropriate to ask about the specific emotional category being targeted and its intensity on the scale. In contrast, in capturing changes in emotion categories and intensity in everyday life, where relatively gradual changes in arousal levels are expected, it may be advantageous to use the list of EEEs created in this study, given the cognitive load placed on participants.

Table 7. The most chosen EEEs for each emotional category and intensity

		Emotion							
		Trust		Disgust		Anticipation		Surprise	
Emotional intensity	High	kira-kira	68.6%	oeR	54.3%	piri-piri	57.1%	gyaa	71.4%
		uQtoLi	65.7%	gee	51.4%	biku-biku	54.3%		
	Medium	kyuN	54.3%	geQ	60.0%	zawa-zawa*	60.0%	oo	60.0%
		niko-niko	54.3%					dokiQ	60.0%
	Low	uN-uN	71.4%	haRa	65.7%	oya	60.0%	sowa-sowa*	68.6%
						sowa-sowa*	57.1%		
		Emotion							
		Fear		Anger		Joy		Sadness	
Emotional intensity	High	buru-buru	57.1%	mukaQ	28.6%	yoQshaa	91.4%	shiku-shiku	71.4%
				muka-muka	28.6%				
	Medium	zokuQ	62.9%	muka-muka	77.1%	waRi	82.9%	shiku-shiku	77.1%
		biku-biku	60.0%	mukaQ	74.3%				
	low	zawa-zawa*	65.7%	iraQ	68.6%	hoQkoLi	91.4%	shoboN	80.0%

Note. The most chosen EEEs and the percentage of participants who chose those EEEs. If the second most frequently chosen EEE was as frequent as the most frequently chosen EEE (i.e., the difference was only 1% or less), it was listed. Gray shaded EEEs are those chosen more frequently in emotion categories different from the emotion categories assumed in Study 1. The EEEs marked with an asterisk were frequently chosen in multiple categories.

A limitation of this study was that we did not directly compare the recording method using EEE with the method using traditional emotional adjectives. Thus, although we showed that EEE can be used to express a variety of emotions, the advantage of EEE was not clearly demonstrated. We need to use the EEE list created in our study in an ESM study to clarify whether EEEs have an advantage over the use of traditional emotional adjectives. This would require assessing users' response time and cognitive load in future research. In addition, to assess the validity of using

EEEs for ESM, it is important to confirm whether the patterns of variation in emotional states across the days and weeks identified in previous ESM studies (e.g., Csikszentmihalyi & Hunter, 2003), and the emotions likely to be felt during various daily activities (e.g., Zuzanek & Zuzanek, 2015) are replicated when EEEs are used.

3.3 Conclusion

The purpose of this study was to create a list of EEEs that represents emotions to enable Japanese speakers to efficiently evaluate and express their own daily emotions and gut feelings more intuitively when participating in ESM studies. We analyzed how Japanese speakers use EEEs to express a variety of emotions at different intensities, using large-scale data collected from an online survey. In general, although there were differences in size of vocabulary among gender-age groups, typical EEEs used for expressing each emotional category were common across gender-age groups. On the basis of the survey results, we proposed a common list of EEEs for Japanese people to intuitively sample and record in real time their subjective emotions in everyday life when they participate in ESM studies.

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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.

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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