感情が言語処理に与える影響：閾下感情プライミングを用いて
Emotions in language processing: Affective priming in embodied cognition

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Abstract
Social interaction and communication require a responsive ability to read others' subtle emotional reactions, which affect subsequent cognitive activities such as up-down spatial attention. Even brief exposure to an emotionally expressive face can influence cognition, due to what is known as an affective priming effect. For instance, subliminal primes of facial expressions generate gross affective information such as a positive/negative category, influencing evaluations of unrelated novel objects. Given the interconnections between emotions and language, this study assesses the functional role of affective information in processing emotionally and spatially congruent/incongruent sentences when facial expressions are perceived consciously (Experiment 1) or unconsciously (Experiment 2).

Key words: Affective priming, Subliminal perception, Embodied cognition, Sentence judgment task

1. Introduction

Successful social interaction and communication require a responsive ability to read others' subtle emotional reactions. Such conscious perception of other's emotional states affects subsequent cognitive activities and information processing. For example, people can use others' facial expressions as a cue to judge whether a particular object should be avoided ([1], [2]). Emotions are easily and flexibly evoked, for instance, by seeing facial expressions ([3], [4]), watching film clips ([5], [6]), looking at pictures ([7]), and thinking of happy or sad life events ([8], [9]). Such conscious emotional states are known to affect one's own cognitive abilities. For instance, one's emotions can expand or narrow one's spatial span of attention ([10], [11]). Moreover, positive emotions can generate greater cognitive flexibility and facilitate a broader focus ([12]), while negative emotions can elicit a narrower cognitive focus ([13]).

Even when exposure to an emotionally expressive face is extremely brief so that emotion is elicited unconsciously, it influences our cognition, due to what is known as an affective priming effect. When emotion is generated outside of conscious awareness, it is diffuse in nature. And an induced emotion "spills over" into the processing of unrelated stimuli. For instance, subliminal primes of facial expressions unconsciously evoke gross affective information such as a positive/negative category, influencing experimental participants' preferences for unrelated target stimuli such as novel objects and Chinese ideographs ([14], [15]). Interestingly, however, research has shown that the affective priming effect of facial expressions disappears with longer exposure durations (i.e., over 1000ms). One possible explanation is that longer exposure to facial expressions not only elicits conscious emotions, but also activates more complex visually based information related to gender, age, hair color, and so on, erasing or overwhelming the affective priming effect ([14]).

Affective information interacts not only with non-linguistic processing such as evaluations and preferences regarding objects, but also with linguistic processing. Chwilla, Virgillito, and Vissers ([6]) showed that conscious positive/negative emotional states induced by watching film clips immediately affected online semantic processing in language comprehension, reflected by an interaction between emotions and N400 amplitude in response to highly (un)expected critical words in a cloze test. Meier and Robinson ([16]) showed that processing the positive/negative valence of affective words unconsciously activated upper/lower parts of visual space and modulated attentional focus, reinforcing the previously established association of emotionally positive (negative) valence with upward (downward) movement (i.e., embodied cognition, [17], [18]). Adopting Strack, Martin, and Stepper's method ([4]) of manipulating participants' facial expressions by having them hold a pen between the teeth to induce smiling or between the lips to induce frowning, Havas, Glenberg, and Rinck ([3]) found effects on reading times and judgment times for sentences describing pleasant or unpleasant situations. In this study, emotion/affective state is unconsciously generated by the posture, and an association between the posture and the affect generated by the sentence influenced language processing.

In summary, there are many interconnections between emotions and language, including the language used to describe emotion and spatial orientation. What is less clear is how these connections play out in response to conscious versus unconscious perception of emotionally relevant stimuli and different types of language. This study assesses the functional role of affective information in processing emotionally and spatially congruent/incongruent sentences when facial expressions are perceived consciously (Experiment 1) or unconsciously (Experiment 2).

2. Predictions

We predicted that sentences that require the activation of positive/negative categorical information, whether due to their emotional information or spatial information (e.g., upward/downward), would be facilitated by the perception of a congruent emotional stimulus and hindered by the perception of an incongruent stimulus.

We also explored how different durations of valenced visual stimuli influence and interact with the subsequent sentence comprehension processes. A conscious exposure to facial expressions evokes not only affective information, but also complex visual information unrelated to the sentences. Therefore, we predict that longer exposures might attenuate the affective priming effect, especially on the spatial sentences.

In contrast, because subliminal exposure to facial expressions only evokes gross affective information, it should be integrated into the processing of positive/negative affective sentences that belong to the same emotional category as the affective primes, and upward/downward spatial sentences, which are cognitively associated with affective primes. When prior activated information matches the subsequent sentences, a facilitation effect should be observed, while mismatches should lead to an interference effect.

3. Experiment 1

3.1 Participants

Fifty-four right-handed native speakers of Japanese (M_{age} = 20.3, F = 45) participated in a sentence judgment task with affective priming.

3.2 Experimental materials

Picture materials: To prime affective valence, we used two female and two male normed images representing positive and negative facial expressions (ATR-promotions, 2006).

Sentence materials: The target sentence materials were 24 sets of affective (positive/negative/neutral) and 24 sets of spatial (up/down/neutral) sentences in Japanese, as illustrated in (1–2). Within each set, the three types of sentences (a-c) were minimally different triplets except for a critical affective or spatial word.

(1) **Affective sentences**

(a) Positive: Keisei-ga *yuurini* narimashita.
situation-NOM advantageous became
'The situation became advantageous.'

(b) Negative: Keisei-ga *hurini* narimashita.
situation-NOM unfavorable became
'The situation lost ground.'

(c) Neutral: Keisei-ga *gyakuten* shimashita.
situation-NOM reversal became
'The situations were reversed.'

(2) **Spatial sentences**

(a) Up: Hashigo-o *nobotte*-imasu.
ladder-ACC climbing

'(Somebody is) climbing the ladder.'

(b) Down: Hashigo-o *kudatte*-imasu.
ladder-ACC going down
'(Somebody is) going down the ladder.'

(c) Neutral: Hashigo-o *tukatte*-imasu.
ladder-ACC using
'(Somebody is) using the ladder.'

Affective sentences were used to assess whether perception of facial expressions facilitates emotionally congruent sentences and hinders emotionally incongruent ones. We intentionally avoided using explicitly emotional vocabulary, such as *happy*, *excited*, *sad*, or *depressed*, in order to assess how affective information interacts with conceptually or semantically congruent sentences, not with linguistically congruent ones.

Moreover, spatial sentences were utilized due to the known association of emotionally positive (negative) valence with upward (downward) movement. One manifestation of the association is in conceptual metaphors such as GOOD IS UP and BAD IS DOWN, linguistically exemplified in figurative expressions such as *I'm feeling up/My spirits rose* and *I'm feeling down/My spirits sank*, respectively ([18]). Positive valence is conceptually linked to spatially upward movement and negative valence to downward movement.

Participants read 48 target sentences expected to elicit YES responses to an acceptability judgment task and 24 fillers (12 affective/12 spatial semantically anomalous or grammatically incorrect sentences) expected to elicit NO responses. The 72 target and filler sentences were presented in random order.

3.3 Experimental design

The experiment had a 2 (Facial expression: Positive/Negative) x 2 (Sentence category: Affective/Spatial) x 3 (Sentence type: Positive/Neutral/Negative for Affective sentences, Up/Neutral/Down for Spatial sentences) repeated-measures design. Six presentation lists were created following a Latin-square design so that each participant saw each target sentence only once in either one of six conditions (2 facial expression conditions x 3 sentence type conditions). Each sentence was paired with a specific male or female picture across the lists. After adding 24 filler sentences to each list, the presentation order was randomized for each participant.

3.4 Procedure

Following a fixation cross, participants saw an image of an emotionally negative or positive facial expression for 200ms. The 200ms duration of the affective prime was visible for long enough for participants to recognize the facial expression. After 50ms of blank screen, a sentence appeared on the screen. Participants provided judgements of the correctness of the sentence by pressing keys labeled "Yes" (the J key) or "No" (the F key) on a keyboard, following instructions to do so as quickly and accurately as possible. We analyzed accuracy and response times (RTs).

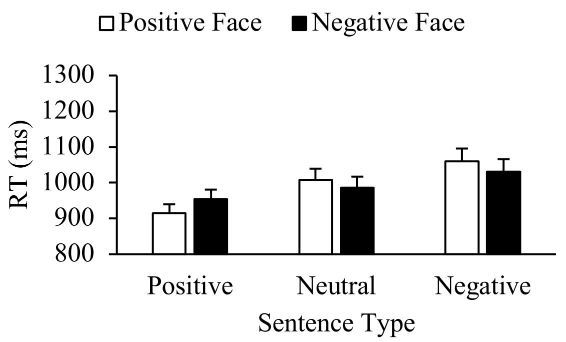
3.5 Results

Using the lme4 ([19]) and the lmerTest ([20]) packages within the R programming language ([21]), a linear mixed-effects model analysis was conducted for the RT data from the target trials, with participants and items as random factors ([22]). We excluded incorrect responses (5.82% of the target trials) and target trials in which RTs were shorter than 500ms or longer than 5000ms (0.42% of the target data). For each participant, trials in which the RT was 2.5 *SD* above or below that participant's mean (2.92% of the target data) were also excluded. Facial expression (Positive/Negative) and Sentence type (Positive/Neutral/Negative for Affective sentences, Up/Neutral/Down for Spatial sentences) were fixed effects with interactions between the factors; the analyses were conducted separately for each sentence category. Facial expression conditions were deviation-coded, and sentence type conditions were treatment-coded with the Neutral condition as the reference level.

Figure 1 shows the mean RTs for each experimental condition, and Tables 1 and 2 show the results of the statistical analyses. As shown in Table 1, the results of the analysis for Affective sentences revealed a significant interaction between Face and Positive sentence type. For Affective sentences, we conducted a further analysis in which the Neutral sentence type was omitted and facial expression conditions were re-coded as Match or Mismatch (with Sentence type): positive (negative) facial expression condition coinciding with positive (negative) sentence type was re-coded as Match, and negative (positive) facial expression condition coinciding with positive (negative) sentence type was re-coded as Mismatch. We call this new variable Congruency. The result revealed a significant main effect of Congruency (β = –38.5, *SE* = 17.2, *t* = –2.24, *p* = .026) and Sentence type (β = –119.0, *SE* = 17.2, *t* = –6.92, *p* < 001). The interaction between Congruency and Sentence type was not significant (β = –20.3, *SE* = 34.5, *t* = –0.59, *p* = .557).

No significant effects were observed for affective primes on the spatial sentences in the primary analysis (Table 2). For Spatial sentences, we also conducted the analysis using the Congruency variable (positive [negative] facial expression condition with up [down] sentence type was re-coded as Match; negative [positive] facial expression with up [down] sentence type was re-coded as Mismatch). The results revealed a significant main effect of Congruency (β = –49.3, *SE* = 22.7, *t* = –2.17, *p* = .031), while the main effect of Sentence type (β = –48.1, *SE* = 31.4, *t* = –1.53, *p* = .141) and the interaction between Congruency and Sentence type (β = –78.0, *SE* = 45.5, *t* = –1.72, *p* = .087) were not significant.

(a) Affective Sentences



(b) Spatial Sentences

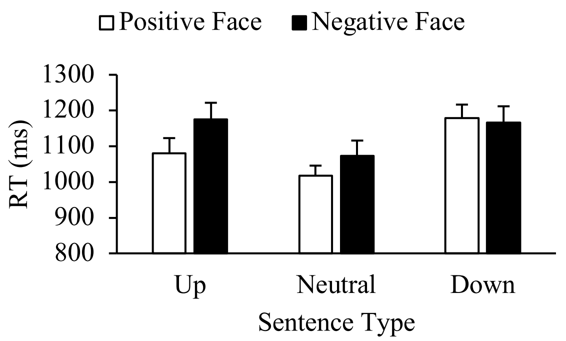


Figure 1: Mean RTs (Experiment 1) for each Face and Sentence type condition by Sentence category (Affective/Spatial). Error bars denote SEs of the mean by participant.

Table 1: Linear mixed-effects regression results for Affective sentences (Experiment 1)

	β	*SE*	*t*
Face	24.9	25.6	0.97
Type (P)	–59.3	18.1	–3.29**
Type (N)	58.5	18.3	3.20
Face × Type (P)	–73.1	36.0	–2.03*
Face × Type (N)	3.7	36.5	0.10

Note. P = Positive sentence; N = Negative sentence.
*p < .05. **p < .01.

Table 2: Linear mixed-effects regression results for Spatial sentences (Experiment 1)

	β	*SE*	*t*
Face	–35.7	31.1	–1.15
Type (U)	79.1	21.9	3.62**
Type (D)	130.4	22.3	5.84**
Face × Type (U)	–59.5	43.8	–1.36
Face × Type (D)	49.5	44.6	1.11

Note. U = Up sentence; D = Down sentence.
*p < .05. **p < .01.

We also conducted logistic mixed-effects model analyses for accuracy data in a similar manner to the RT analysis; there were no significant effects of the fixed factors or interactions between them in either the affective and spatial sentences. The mean accuracy rates are summarized in Table 3.

Table 3: Mean (*SD*) accuracy rates for Experiment 1.

	Face	
	Positive	Negative
Affective sentence		
Positive	97.5 (7.9) %	98.6 (5.8) %
Neutral	95.8 (10.6) %	95.7 (12.0) %
Negative	93.5 (13.0) %	97.2 (7.9) %
Spatial sentence		
Up	93.4 (12.4) %	95.2 (10.2) %
Neutral	90.0 (15.3) %	93.1 (12.3) %

Down	92.6 (11.5) %	87.7 (18.1) %

4. Experiment 2

4.1 Participants

A new set of 54 right-handed native speakers of Japanese (M_{age} = 20.8, F = 30) participated in Experiment 2.

4.2 Experimental design and Procedure

Experimental design, materials, and procedures in Experiment 2 were identical to those in Experiment 1, except that the affective prime was subliminally presented for 17ms and followed by a 183ms visual mask (i.e., 200ms total, equivalent to the 200ms duration of the affective prime in Experiment 1).

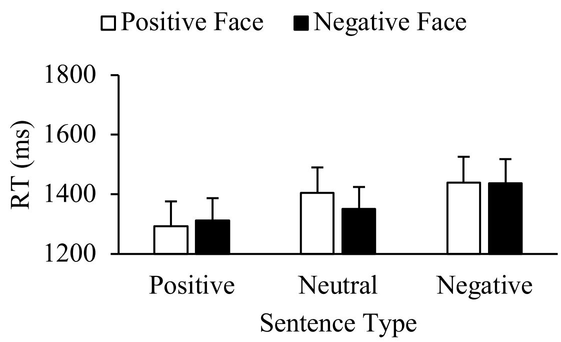
4.3 Results

We performed the same data treatment and statistical analyses as those in Experiment 1. We excluded incorrect responses (6.26% of the target trials) and responses in which the RT was shorter than 500ms or longer than 5000ms (1.97% of the target trials). For each participant, trials in which the RT was 2.5 *SD* above or below the mean (2.72% of the target data) were also excluded.

Figure 2 shows the mean RTs for each experimental condition, and Tables 4 and 5 show the results of the statistical analyses. As shown in the tables, in contrast to the results in Experiment 1, the results in Experiment 2 demonstrate an affective priming effect on the spatial sentences, but no effect on the affective sentences. More specifically, the results of the analysis for Spatial sentences revealed a significant interaction between Face and Down sentence type. As in Experiment 1, we conducted the analysis using the Congruency variable for Spatial sentences. The result revealed a significant main effect of Congruency ($\beta = -82.7$, $SE = 31.9$, $t = -2.59$, $p = .010$). The main effect of Sentence type ($\beta = -50.0$, $SE = 41.4$, $t = -1.21$, $p = .240$) and the interaction between Congruency and Sentence type were not significant ($\beta = 50.4$, $SE = 63.8$, $t = 0.79$, $p = .430$).

There were no significant effects of affective primes on the affective sentences (Table 4). The analysis with the Congruency variable found no significant main effect of Congruency ($\beta = -14.9$, $SE = 30.2$, $t = -0.49$, $p = .623$) nor significant interaction between Congruency and Sentence type ($\beta = -45.9$, $SE = 60.5$, $t = -0.76$, $p = .448$). The main effect of sentence type was significant ($\beta = -153.1$, $SE = 30.3$, $t = -5.06$, $p < .001$).

(a) Affective Sentences



(b) Spatial Sentences

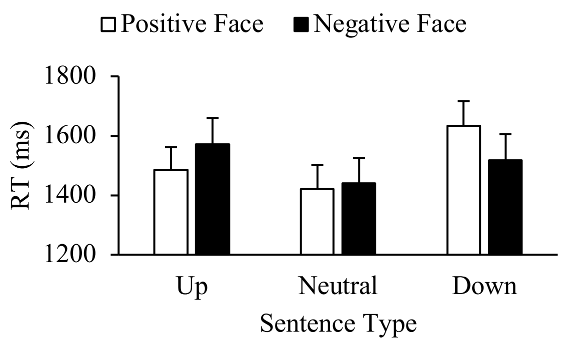


Figure 2: Mean RTs (Experiment 2) for each Face and Sentence type condition by Sentence category (Affective/Spatial). Error bars denote SEs of the mean by participant.

Table 4: Linear mixed-effects regression results for Affective sentences (Experiment 2)

	β	*SE*	*t*
Face	42.4	43.7	0.97
Type (P)	–78.9	30.7	–2.57*
Type (N)	75.4	31.3	2.41*
Face × Type (P)	–80.9	61.4	–1.32
Face × Type (N)	–48.6	62.4	–0.78

Note. P = Positive sentence; N = Negative sentence.
*$p < .05$. **$p < .01$.

Table 5: Linear mixed-effects regression results for Spatial sentences (Experiment 2)

	β	*SE*	*t*
Face	–26.0	44.1	–0.59
Type (U)	110.1	31.6	3.49^{**}
Type (D)	164.6	31.6	5.22^{**}
Face × Type (U)	–34.9	62.7	–0.56
Face × Type (D)	133.9	63.1	2.12^{*}

Note. U = Up sentence; D = Down sentence.
$^{*}p < .05$. $^{**}p < .01$.

Logistic mixed-effects model analyses for accuracy data found no significant effects of the fixed factors or interactions between them, for both affective and spatial sentences. The mean accuracy rates are summarized in Table 6.

Table 6: Mean (*SD*) accuracy rates for Experiment 2.

	Face	
	Positive	Negative
Affective sentence		
Positive	90.4 (15.7) %	95.1 (10.6) %
Neutral	94.6 (10.9) %	92.9 (11.6) %
Negative	92.4 (12.8) %	89.0 (17.0) %
Spatial sentence		
Up	96.3 (10.2) %	96.3 (11.3) %
Neutral	95.4 (9.8) %	96.3 (13.2) %
Down	92.9 (13.9) %	92.3 (14.7) %

5. General Discussion

This study showed that the participants' conscious and unconscious perception of emotional stimuli played a role in their comprehension of affective and spatial sentences in different ways. Surprisingly, the findings of Experiment 1 demonstrate that consciously captured emotion-driven information influences comprehension of affective and spatial language. A conscious exposure to facial expressions evoked not only gross affective information, but also perceptual information of specific facial features ([23]). Therefore, early affective information might interact with subsequently processed information of spatial sentences while late specific features of facial information interact with affective sentences. People's general preference for positive valence might explain why the valence congruency effect was observed more strongly in positive sentences ([24], [25]), than in negative ones.

Against our predictions, in Experiment 2, extremely brief exposure to facial expressions influenced only spatial sentences, which are cognitively associated with affective primes, while it did not influence affective sentences. Because of the diffuse quality of the emotional valence of subliminal stimuli, it seems that gross positive/negative information selectively influences the processing of spatial sentences that are not affective in nature. This might suggest that the core or fundamental information of gross facial perception is up/down in nature and carries no emotional valence, which would explain why affective priming effects were only observed in spatial sentences, but not in affective sentences. Our results also support the embodied cognition theories proposing an interactive or interconnected relation between emotional concepts (positive/negative) and spatial concepts (up/down) in language comprehension.

It is known that individuals with high empathy and those with low empathy differ in their perceptive abilities and attentional focus. For instance, individuals with high empathy tend to not only pay attention to human faces more than those with low empathy ([26]), but also to read others' facial expressions more accurately than those with low empathy ([27]). Moreover, individuals with low empathy pay more attention to a specific area or feature when perceiving a face, while those with high empathy perceive a face by scanning it in a broader manner ([12], [13]). Since the two experiments had different participants, it is possible that differences in empathy influenced the pattern of the results. Hence, in future research, we plan to explore how individuals' personal traits such as empathy interact with affective perception and language processing.

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