1. Introduction

There have been numerous studies on pronouns and metaphors in the field of linguistics (Chomsky (1981), Reinhart (1983), Lakoff and Johnson (1980)). These researches have not focused on physiological aspects but on phenomenological inclinations. When researchers would like to extract mental principles from certain linguistic phenomena, theoretical approaches and psychological experiments are invaluable. However, those methods do not seem suited to identifying which the phenomena consist of, as compared with physiological experiments. There should be many things elucidated only after researchers investigated brain reactions upon linguistic processing.

This paper is intended as an investigation into the brain regions that get activated when human beings process pronouns in 'extension-requiring' condition. From the results, a working model of words in 'extension-requiring' condition such as metaphors will be proposed. Although some data used in this paper are the same as those utilized in Maruyama (2003), new data such as activated axis have been added and activation of the brain regions are reanalyzed.
The first point to be discussed is the definition of the term 'extension-requiring'. See the following sentence (see Note 1).

(1) Adzusa wa boku no taiyou-da

Adzusa TOP I POS sun-be-PRE

'Adzusa is my sun.'

Adzusa is a female name in Japanese, and human beings cannot be a fixed star. However, sentence (1) is interpretable. Native Japanese speakers construe the meaning of sentence (1) as 'Adzusa is the dearest person and hope for boku'. That is to say, native Japanese speakers extend the semantic range of the word taiyou in order to grasp the sentence naturally. Thus, the word 'extension-requiring' can be defined as a situation where words stand for different information from their signifiants, and in order to understand the referent, human beings have to extend semantic range of the words.

This 'extension-requiring' situation can be also seen in some sentences containing certain pronouns.

(2) Aturo wa Tadanobu ni kare no himitu o

Aturo TOP Tadanobu DAT he POS secret OB

akasita
tell-PAST

'Aturo told Tadanobu his secret.'
Pronoun *kare* in sentence (2) does not indicate the person named *kare*, and itself is a variable. In other words, *kare* in sentence (2) can be *Aturo*, other person outside the sentence, *Aturo’s* or someone else’s boyfriend and so on (see Note 2). Native Japanese speakers may extend the semantic range of the pronoun *kare* and choose the most plausible candidate along the sentence or, if they can, utilize context in order to identify what the pronoun stands for. This operation seems to be similar to that employed in construing metaphorical expressions. However, this idea is just a speculation, and physiological evidence is required for proving whether this is so. If those two linguistically different usages make use of similar neural circuit, then their physiological reaction will be also similar.

If this experiment reveals that there are physiological similarities between processing pronouns in 'extension-requiring' condition and metaphors, it will be capable of hypothesizing a working model with which human beings process words in 'extension-requiring' condition. The working model will contribute to shedding light on the human language system.

2. Experiment

2.1 Recording Procedure

This experiment employed fMRI, which was approximately the instrument of imaging neural activities by using ‘blood oxygenation level dependent effect (BOLD)’ (see Note 3). Subjects participating this test
laid on their backs on the bed equipped with fMRI, and they saw the screen above their faces. Stimulus sentences were presented on the screen, and subjects tried to respond to them by pressing either right or left button with their thumbs. The right button corresponded to choice A and the left button, to choice B. During the time the subjects performed the tasks, the fMRI registered their brain activities of them.

2.2 Subjects
Five right-handed normal male volunteers, mean age 21 years (range 19-24 years) participated in this experiment. All had Japanese as their first language. They all have never experienced brain injury. They were high-educated and received university or graduate education.

2.3 Stimuli and plausibility judgment task
All the stimuli can be divided into three types: (i) sentences whose pronominal gender is the same as both of potential antecedents (ex. Sigeru wa Taro ni kare ga kekkon-suru koto o akasita. [Sigeru disclosed to Taro that he was going to get married]), (ii) sentences whose pronominal gender is the same as either potential antecedents (ex. Yuriko wa Taizi ni kanozyo ga rikon-suru koto o tutaea. [Yuriko said to Taizi that she was going to divorce]), and (iii) sentences containing metaphorical expressions (ex. Maikuro-sohuto-sya wa bizinesu-kai no tora-dearu. [Microsoft Corporation is a tiger of business world]). Added to this, stimuli in (i) and (ii) have at least two personal names, and do not
How Human Beings Process the Words in 'Extension-Requiring' Condition have pronouns at the subject positions in main clause (see Note 4). Underlines were drawn under either pronoun or metaphorical expression in each question, and two choices (A and B) were presented below each stimulus. Each stimulus was presented for ten seconds, and during the period, subjects were directed to choose A or B as having the same referent as the underlined pronoun. See the following example.

(3) Taro wa Jiro ni kare no hon o kaesu
Taro TOP Jiro DAT he POS book OB give-back
to yakusokusita
COMP promise-PAST
'Taro promised to give back Jiro his book back.'
A: Taro B: Jiro

The plausible choice is B. *kare* in the sentence (3) indicates *Jiro* (see Note 5).

Also, since subjects could randomly press the buttons without thinking and, needless to say, those random choices are irrelevant to abilities of processing pronouns in 'extension-requiring' condition and metaphors, their scores are registered. With doing this, it is able to exclude the questionable data (though my subjects performed far beyond 75% correct).
2.4 Analytic Framework

There are several task designs in neuroimaging study and the design this experiment employed was categorical design. Categorical design is the simplest design and also called cognitive subtraction design. Roughly speaking, this design is utilized when experimenters would like to compare cognitive ability 1 with 2 (see Note 6). See the chart below.

(4)

<table>
<thead>
<tr>
<th>Cognitive Ability 2</th>
<th>×</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Ability 1</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

Task I  Task II

Given there are two heterogeneous cognitive abilities 1 and 2. In order to solve task I, human beings only employ cognitive ability 1, while they utilize both cognitive abilities 1 and 2 to respond to task II. When experimenters subtracts brain activation related to solving task I from that connected to processing task II, they can specify activation which is only required to process task II, namely cognitive ability 2 here.

Given, as an example, experimenters try to make a comparison between two tasks; (G) seeing letters on fMRI screen and (H) writing the same letters on paper as the screen shows. Tasks (G) and (H) seem to share similar or the same visual ability, since participants cannot perform task (H) unless they see the screen. Thus, when experimenters subtract activation in task (G) from that in task (H), they can find brain
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regions related to an ability of 'writing'.

Then, the groups of my experiment should be noted. As written in section 2.2, since my experiment involves three tasks, it is capable of setting six compared groups as follows:

(5)

Group 1: ((i) sentences whose pronominal gender is the same as both of potential antecedents minus (ii) sentences whose pronominal gender is the same as either potential antecedents)

Group 2: ((i) sentences whose pronominal gender is the same as both of potential antecedents minus (iii) sentences containing metaphorical expressions)

Group 3: ((ii) sentences whose pronominal gender is the same as either potential antecedents minus (i) sentences whose pronominal gender is the same as both of potential antecedents)

Group 4: ((ii) sentences whose pronominal gender is the same as either potential antecedents minus (iii) sentences containing metaphorical expressions)

Group 5: ((iii) sentences containing metaphorical expressions minus (i) sentences whose pronominal gender is the same as both of potential antecedents)

Group 6: ((iii) sentences containing metaphorical expressions minus (ii) sentences whose pronominal gender is the same as either potential antecedents)
Finally and most importantly, how does one judge whether processing pronouns require similar ability to process metaphorical expressions? My experiment mainly relies on the results from Bottini et al. (1994). Bottini et al. let six subjects perform three different linguistic tasks: metaphorical comprehension; literal comprehension of sentences; and a lexical comprehension of sentences. In the metaphorical sentences task, Bottini et al. asked six subjects to decide whether presented sentences were plausible metaphors or not. The subjects tried to decide whether the presented sentences were plausible or implausible at the literal level of analysis in the literal sentence task. In the lexical-decision task, the subjects attempted to indicate whether a non-word was presented within a sentence-like string of eight to nine words. The half of the presented strings contained an orthographically legal non-word derived from the modification of an English word. Examples are as follows.

(6)

Metaphorical task-examples

(6a) The investors were squirrels collecting nuts. (Pl.)
(6b) The investors were trams. (impl.)

Sentence task-examples

(6c) The boy used stone as paperweights. (Pl.)
(6d) Tim used feathers as paperweights. (impl.)

The lexical decision task

(6e) hot lamp into confusing after bencil entrance stick real
How Human Beings Process the Words in 'Extension-Requiring' Condition

(6f) fun through travelling me opportunity sky in out short

(Pl. stands for that the sentence is plausible, while impl. Means that the sentence is implausible.)

(Bottini; 1994)

Bottini et al. employed PET, another kind of neuroimaging, to capture brain activation in six subjects, and stimuli were delivered on a computer screen appearing at a rate of one sentence or string of words every five seconds. When they subtracted activation in processing literal sentences from that related to metaphorical processing, they observed significant activations in the following regions (see Note 7).

(7) Activated Areas shown in the experiment of Bottini et al. (1994)

Activation in processing metaphors minus that in processing literal sentences

<table>
<thead>
<tr>
<th>Area</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA 8 (right)</td>
<td>34</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>BA 46 (right)</td>
<td>40</td>
<td>28</td>
<td>8</td>
</tr>
<tr>
<td>Anterior cingulate: BA 32 (mesial)</td>
<td>-2</td>
<td>42</td>
<td>8</td>
</tr>
<tr>
<td>Middle temporal gyrus: BA 21 (right)</td>
<td>56</td>
<td>-38</td>
<td>0</td>
</tr>
<tr>
<td>Posterior cingulate: BA 31 (right)</td>
<td>18</td>
<td>-40</td>
<td>28</td>
</tr>
<tr>
<td>Precuneus: BA 31 (right)</td>
<td>18</td>
<td>-62</td>
<td>20</td>
</tr>
<tr>
<td>BA 8 (left)</td>
<td>-14</td>
<td>16</td>
<td>52</td>
</tr>
<tr>
<td>BA 9 (left)</td>
<td>-36</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>BA 8 (left)</td>
<td>-32</td>
<td>10</td>
<td>44</td>
</tr>
</tbody>
</table>
Grounded on the results above, Brownell (2000) argues that processing metaphors requires the abilities derived from, especially, the dorsolateral prefrontal region (BA 46), the middle temporal gyrus (BA 21), and the Precuneus, located in the middle parietal lobe (BA 31) in the right hemisphere.

If those data above are correct, the following formula can be hypothesized.

\[
(8) \quad \text{Activation in processing metaphors} - \text{Activation in processing extension-requiring pronouns} = X
\]

\[
\text{Activation in processing extension-requiring pronouns} - \text{Activation in processing metaphors} = Y
\]

That is, if neither X nor Y shows activations in BA 46, BA 21, and BA 31, the processing of both metaphors and pronouns require abilities derived from those three areas. That is to say, if these two processes both activate three brain regions in question, activations will be counterbalanced when they are subtracted from each other.
3 Results And Discussion

3.1 Results

When activations related to processing pronouns were subtracted from those in metaphorical processing, the remaining activations observed were in the following regions (see Note 8). On the top left picture, the right side corresponds to the front part of head and the upper side corresponds to the top part of head. On the top right picture, the right side illustrates the right hemisphere and the upper side illustrates the top part of head. On the bottom picture, the upper part indicates the left hemisphere and the right side indicates the front part of head.

Table 1
Activated areas of Group 5: ((iii) sentences containing metaphorical expressions minus (i) sentences whose pronominal gender is the same as both of potential antecedents)

<table>
<thead>
<tr>
<th>Area</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paracentral Lobule, White Matter (left)</td>
<td>-4</td>
<td>-15</td>
<td>45</td>
</tr>
<tr>
<td>Medial Frontal Gyrus, Gray Matter (left)</td>
<td>-4</td>
<td>49</td>
<td>-14</td>
</tr>
<tr>
<td>Uncus, Gray Matter: BA 28 (left)</td>
<td>-22</td>
<td>4</td>
<td>-27</td>
</tr>
<tr>
<td>Medial Frontal Gyrus, Gray Matter: BA 10 (left)</td>
<td>-3</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Right Cerebellum, Culmen (right)</td>
<td>4</td>
<td>-49</td>
<td>0</td>
</tr>
<tr>
<td>Culmen (left)</td>
<td>-4</td>
<td>-51</td>
<td>0</td>
</tr>
</tbody>
</table>
How Human Beings Process the Words in 'Extension-Requiring' Condition

Table 2
Activated areas of Group 6: ((iii) sentences containing metaphorical expressions minus (ii) sentences whose pronominal gender is the same as either potential antecedents)

<table>
<thead>
<tr>
<th>Area</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior Cingulate (mesial)</td>
<td>0</td>
<td>-49</td>
<td>12</td>
</tr>
<tr>
<td>Superior Temporal Gyrus, Gray Matter: BA 38 (right)</td>
<td>53</td>
<td>13</td>
<td>-21</td>
</tr>
<tr>
<td>Rectal Gyrus (left)</td>
<td>0</td>
<td>36</td>
<td>-21</td>
</tr>
<tr>
<td>Medial Frontal Gyrus, Gray Matter: BA 10 (left)</td>
<td>-7</td>
<td>54</td>
<td>0</td>
</tr>
</tbody>
</table>
In contrast, subtracting activations connected to processing metaphors from those associated with processing pronouns, the following regions were activated.

Table 3
Activated areas of Group 2: ((i) sentences whose pronominal gender is the same as both of potential antecedents minus (iii) sentences containing metaphorical expressions)
How Human Beings Process the Words in 'Extension-Requiring' Condition

![Brain Image](image)

**SPM Results**
- **Height threshold** $T = 3.11$
- **Extent threshold** $k = 0$ voxels

**Brain Image (i) minus (iii)**

<table>
<thead>
<tr>
<th>Structure</th>
<th>$x$</th>
<th>$y$</th>
<th>$z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Occipital Gyrus, Gray Matter: BA 18 (left)</td>
<td>-29</td>
<td>-94</td>
<td>7</td>
</tr>
<tr>
<td>Cuneus, Gray Matter: BA 17 (left)</td>
<td>-17</td>
<td>-80</td>
<td>7</td>
</tr>
<tr>
<td>Cuneus, White Matter (right)</td>
<td>21</td>
<td>-63</td>
<td>53</td>
</tr>
<tr>
<td>Precuneus, Gray Matter: BA 7 (right)</td>
<td>3</td>
<td>-63</td>
<td>53</td>
</tr>
<tr>
<td>Right Cerebellum, Posterior Lobe, Pyramis (right)</td>
<td>3</td>
<td>-77</td>
<td>-25</td>
</tr>
<tr>
<td>Middle Temporal Gyrus, White Matter (left)</td>
<td>-55</td>
<td>-48</td>
<td>7</td>
</tr>
<tr>
<td>Middle Occipital Gyrus, Gray Matter: BA 18 (left)</td>
<td>-30</td>
<td>-94</td>
<td>7</td>
</tr>
<tr>
<td>Cuneus, Gray Matter: BA 17 (left)</td>
<td>-17</td>
<td>-80</td>
<td>7</td>
</tr>
<tr>
<td>Superior Temporal Gyrus, White Matter (right)</td>
<td>61</td>
<td>-39</td>
<td>7</td>
</tr>
</tbody>
</table>
How Human Beings Process the Words in 'Extension-Requiring' Condition

Sub-lobar, Insula, Gray Matter: BA 13 (left) -36 19 7
Sub-lobar, Caudate, Gray Matter, Caudate Body (left) -5 10 7
Inferior Frontal Gyrus, Gray Matter: BA 45 (right) 50 25 7
Middle Frontal Gyrus, White Matter (right) 37 53 7

Table 4
Activated areas of Group 4: ((ii) sentences whose pronominal gender is the same as either potential antecedents minus (iii) sentences containing metaphorical expressions)

![Brain Image](image-url)
3.2 Discussion

The experiment showed that processing stimuli (i) did not give rise to activations in BA 46, BA 21, and BA 31 in the right hemisphere when compared with processing metaphors, and, likewise, processing metaphors did not show activation in those three regions when activation associated with processing stimuli (i) were subtracted from that in processing metaphors. If what Bottini et al. (1994) proved is not English-specific phenomenon, these two linguistically heterogeneous processes require those three regions.

The most interesting finding of this fMRI study was that neither processing stimuli (ii) gave rise to activations in BA 46, BA 21, and BA 31, and nor the counter-task, namely Group 6: ((iii) sentences containing metaphorical expressions minus (ii) sentences whose pronominal gender
is the same as either potential antecedents), activated those three regions. The sentence below is a sample of stimulus type (ii).

(9) Taro wa Yosiko ni kanozyo no tanzyobi
    Taro TOP Yosiko DAT she POS birthday
    o kiita
    OB ask-PAST

'Taro asked Yosiko when her birthday was.'
A: Taro B: Yosiko

In this case, human beings seem to be able to identify what the underlined pronoun stands for with gender feature checking. If stimuli (ii) require usual language processing, activation will be partial to the left hemisphere, and the right hemispheric regions activated in metaphor processing should remain in Group 6. However, several right hemispheric activation including BA 46, 21, and 31 could not be seen in Group 6. This is the evidence that, even when processing stimuli (ii), human beings extend the semantic range of given pronouns.

Then, from the results, the brain regions that get activated in processing 'extension-requiring' pronouns should be tentatively specified as follows (see Note 9).

(10) Processing pronouns in 'extension-requiring' condition
    BA 46 (right), BA 21 (right), BA 31 (right), The Right Language Areas
Since the sizes of activated brain regions of Groups 2 and 4 (roughly, groups 'pronouns minus metaphors') are much larger than those of Groups 5 and 6 (groups 'metaphors minus pronouns'), it is plausible to assume that processing pronouns in 'extension-requiring' condition seems to demand extra computation in addition to the extension used when human beings interpret metaphors.

Extra computation is supposedly the computation of intrinsically action and conditional change which verbs convey. Although all the sentence processing certainly includes verbal computation, the importance of the computation in processing pronouns in 'extension-requiring' condition seems to be much heavier. That is to say, when processing pronouns in the condition, human beings may require not only information of relation between words in subject-position, dative-position and object-position, but also extra verbal computation of which the objects ultimately revert to. The verbs 'lend' and 'return' are suitable for the example.

(11)

\[ J \text{ ga } K \text{ ni kare/kanozyo no } L \text{ o } M \text{ (verb)} \]
\[ J \text{ TOP K DAT he/she POS L OB M (verb)} \]

'J M Pronoun's L to K.'
How Human Beings Process the Words in 'Extension-Requiring' Condition

Suppose J and K are proper names and of the same sex, L is a material, and M is a verb. If the verbs 'lend' and 'return' are inserted in M above, two outputs share the same information: Pronoun's L moves from J to K. However, the original possessor of Pronoun's L is different between these two. In the case that verb 'lend' is inserted, J is the proprietor of Pronoun's L when there are only two choices (J or K), and in the case of the verb 'return', Pronoun's L originally reverts to K. This kind of extra verbal computation plays significantly important role in identifying referent of pronouns. In other words, without this computation, human beings cannot decide what Pronoun's L refers to. Moreover, extension may take place not only on pronouns but also on verbs in this condition. Without intrinsically action and conditional image extraction of verbs, human beings cannot achieve extra computation accurately. The five brain regions in (10), therefore, seem to be in charge of extension and extra computation. However, this is just tentative speculation, and further researches will be required.

Finally, the working model of processing sentences with words in 'extension-requiring' condition should be as follows. A, B, C, and D in (12) stand for lexical items, and ? means that the word is unidentifiable. Horizontal arrows show that human beings process sentences in the direction. ↓↑ means that those pointed words are extended.

(12) A working model of processing sentences with words in 'extension-requiring' condition
How Human Beings Process the Words in 'Extension-Requiring' Condition

Phase 1: A → B → C → D

Phase 2: A → B → C → D

Phase 3: A → B → C → D

(13) An example of sentence processing (sentence (2)) along the model (12)

Phase 1: Aturo → wa → Tadanobu → ni → kare no himitu o akasita

Phase 2: Aturo → wa → Tadanobu → ni → kare → no → himitu → o → akasita

Phase 3: Aturo → wa → Tadanobu → ni → kare → no → himitu → o → akasita

First, at phase 1, human beings process sentences by exploiting
denotative meanings. They, however, encounter words in 'extension-requiring' condition, namely B. In the case of sentence (2) (Aturo wa Tadanobu ni kare no himitu o akasita. [Aturo told Tadanobu his secret.]), native Japanese speakers should process partial contents of the sentence (from Aturo to ni), and find it unfeasible to identify what kare stands for on the phase 1 as shown in (13). Then, at phase 2, human beings leave those words, and continue to process the rest of the sentence. As in (13), considering the processing of the sentence (2) along this model, native Japanese speakers should finish processing the rest of contents (from kare to akasita) without identifying what kare means on the phase 2. Finally, at phase 3, they try to extend the semantic range of those pronouns and metaphors to several candidates and check which is most plausible. In the case of identifying pronouns in 'extension-requiring' condition, human beings seem to perform both extension (of semantic range of pronouns and verbs) and extra computation. If they succeed in linking unidentifiable words with plausible referent, they can interpret the sentence correctly. If not, sentence processing crashes. In the case of processing sentence (2), at the phase 3, native Japanese speakers should link kare with the plausible candidates (with employing extracted images of verbs) as the way the example (13) shows (see Note 10).

4 Conclusion

This paper has shown physiological similarity between processing metaphors and pronouns in 'extension-requiring' condition, and proposed
How Human Beings Process the Words in 'Extension-Requiring' Condition

the working model of processing sentences with words in the condition. Added to this, this paper tentatively speculates that BA 46 (right), BA 21 (right), BA 31 (right), the right language area (either BA 45 or BA 47) and Middle Frontal Gyrus (right) are in charge of the extension and extra computation when human beings process pronouns in the condition.

All the pronouns are, needless to say, not in 'extension-requiring' condition. For example, in actual conversation, one of the candidates that pronouns can indicate is likely to be primed conspicuously. Furthermore, in even experimental situation, pronouns in subject-position may not be in the condition since the referent will never be identified, and participants should cancel the processing. However, when human beings can neither select the referent nor cancel the processing automatically, they seem to process not-identifiable words along the model that this paper presents.

Notes

Note 1: The abbreviations used in this paper are:


Note 2: hare could stand for a boyfriend and kanozyo, for a girlfriend in Japanese.

Note 3: fMRI used in this experiment is made by Simadzu Marconi Corporation and called MAGNEX 1.5T Power Drive 250. The strength of the static magnetic field is 1.5T and it has the fine tuning function of the magnetic field. The uniformity of the magnetic field is <1ppm/50cm DVS. The strength of the
slant magnetic field is 27mT/m and the velocity of converting the magnetic field is 72mT/m/ms. Devices of presenting visual stimuli are AVOTEC SV4021 and Psychology Software Tools. The scans are done in every six second and amount to one hundred twenty scans plus two scans for tuning. The performance of the CPU is 64 bit/500MHZ. Time of image reconstruction is 0.02sec/slice or 50slices/sec (256 x 256mm). The data of my experiment are analyzed with statistical parametric mapping (namely, SPM; using SPM99 software from the welcome department of cognitive Neurology, London, UK) implemented in MATLAB employing standardized procedures that include realignment, spatial normalization, and smoothing. The threshold is set at $p<0.05$ corrected for different comparisons and the threshold for masks is set at $p<0.001$ uncorrected. The explanation about BOLD is excluded in this paper. If needed, see Maruyama (2003).

Note 4: The questions used in this experiment amounted to seventy-two questions. Since the time required for scanning was thirty seconds, the number of stimuli must be a multiple of 3. Added to this, to make the former and latter potential antecedents have the same frequency of being plausible answers in stimulus type (i), the number of stimuli must be a multiple of 2. Furthermore, since the more fMRI scans, the clearer the statistic images are, my experiment presented as many stimuli as possible in my test scale. That is twenty-four questions in each stimulus type, and three stimulus types add up seventy-two questions.

Note 5: Leaving two choices out of consideration, kare in sentence (3) could indicate other person outside the sentence. To put it the other way round, setting two choices exclude chaotic situation where severaI plausible answers exist.

Note 6: The number of compared abilities can be modified and gained. Experimenters can theoretically observe as many functions as they would
How Human Beings Process the Words in 'Extension-Requiring' Condition like.

Note 7: The number of x axis stands for the horizontal portion of activated regions, that of y axis for depth, and that of z axis for height in the brain. For example, the point x=0 / y=0 / z=0 is the center of the brain. Z scores, which shows statistical intensity, are omitted in this paper. Moreover, if you are unfamiliar with the Brodmann map, see below.

![Brodmann map](image)

(Kandel et al.; 2000)

Note 8: The former analysis employed 5mm capturing; however 5mm is relatively large for identifying the regions that directly work. In this paper, therefore, 3mm capturing are applied.

Note 9: In Groups 2 and 4, there appear several activations at rear brain such as Middle Occipital Gyrus, Superior Parietal Lobule, and so on. These regions associated with vision are supposed to get activated since burdens of visual processing seem to be slightly larger in stimulus types (i) and (ii) than (iii). Also, some of the rest activations in Groups 4 and 6 should be involved in verbal working memory.
How Human Beings Process the Words in ‘Extension-Requiring’ Condition

Note 10: The working model in (12) can be applied to processing metaphors. The sentence (1) (Adzusa wa boku no taiyou-da. [Adzusa is my sun.]) can be an example of the process. When the words in ‘extension-requiring’ condition appear at the last position in sentences, however, the phase 1 in (12) amalgamates with the phase 2. That is to say, at the phases 1 and 2, human beings process the sentence (1) denotationally, and leave over taiyou as not an identifiable word. Then, at the phase 3, human beings link taiyou with the candidates ‘irreplaceable existence’.

Bibliography


