



## Locating Logic Faculty in the Mental System

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### ABSTRACT

Taken from Chomsky's *Knowledge of Language* (1986), it is noted that logical form (LF) is not a direct reflection of deep structure (D-structure). It has induced a question, where is then 'logic' located in the human psychology (in the sense of the mind-system) if it is not in the D-structure. To answer this question, we will try to see how different languages (in this paper, English, Malay and Turkish) are structured differently on the surface (S-structure) yet can have the same internal syntax (D-structure). However, when there is a change in semantics (in the sense of intended meaning), a change in LF is noted, although the D-structure might remain the same. Making sense of this, we argue that D-structure is not the innermost faculty of the human innate system (mind) but rather, how S-structure is to D-structure, that is how D-structure is to the human logic faculty. In other words, with D-structure, logic faculty is more profound.

**Keywords:** cognitive science, theoretical linguistic, mind, psychology, logic

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## 1 INTRODUCTION

Often, within the domain of human psychology (more precisely, cognitive science), logic is studied as the logical use of semantics (for example, see Da Silva, 2017; McKeon, 2020; Römer, bein Graben, Huber-Liebl, & Wolff, 2022). However, in this paper, logic within the domain of psychology is studied beyond semantics. Locating the logic faculty within the human mind's mental system is the study's object. The relationship between the logic faculty and language faculty will be contrasted to achieve this. Language under the study of theoretical linguistics is understood to consist of 'deep structure' (D-structure) and 'surface structure' (S-structure). D-structure in relation to S-structure is internal. If it is argued that the logic faculty is to be contrasted with the language faculty, then it follows that the logic faculty is separated from the D-structure. It concludes that, contrary to (Da Silva, 2017; McKeon, 2020; Römer, bein Graben, Huber-Liebl, & Wolff, 2022), logic is not influenced by external factors despite semantics changed in a change in environment.

If logic is purely a psychological state of mind corresponding to external environments, then the Cartesian conception of the mind is to be rejected. It follows that the study of the science of language ought to be studied in the tradition of behaviourism, and the nature of the mind should be investigated under functionalism's framework. This paper argues against the assumptions of behaviourism and functionalism. To refute this null hypothesis, a thought experiment is done. A group of various languages that articulate the same sentence will be analyzed in two different contexts. The null hypothesis is rejected when it is shown that the logic of the intended meaning is more abstract than the structure of the language in use. The rejection of the null hypothesis affirms the theory that logic faculty is separated from language faculty. Thus, it can be shown that logic is not purely a psychological state of mind corresponding to external environments. Intuition for logic is innate.

## 2 LANGUAGE AND “LOGIC USE” IN LANGUAGE

The study of the science of language is the study of I-language. If language is to be studied as only consisting of syntax and semantics, then only an ineffective amount of knowledge of language can be derived from such study. The line that distinguishes semantics and syntax is unclear (Da Silva, 2017). According to Chomsky (1986), it would be more effective to understand language in terms of I-language and E-language. I-language is the use of language "internally" and "individually", and its mechanism is "intensional". On the other hand, E-language is the use of language "externally," and its mechanism is "extensional".

It is an error to limit the study of E-language as the study of syntax and the study of I-language as the study of semantics. In analyzing I-language, elements of syntax and semantics are noted. To illustrate the elements of syntax and semantics on I-language, reference to D-structure and S-structure is to be made.

If S-structure is understood to be the 'phonetic' form of the sentence, either one voices it out or has it as an inner voice, then D-structure, embedded in the speaker's mind, is the mental image of

the sentence. S-structure can be divided into the structures of syntax and semantics. Its semantics is the D-structure. However, analyzing the D-structure itself, elements of syntax and semantics are noted, too (Da Silva, 2017). Any structure found on the D-structure is a syntax, and the content is semantics.

Further inquiry can show that, within the 'semantics' of the D-structure, another layer of 'syntax-semantics' can be found. A continuous cycle that goes 'deeper' can be assumed. Such dynamism constitutes I-language, and it reflects the theory of generative grammar, which in turn confirms the principle of Universal Grammar (UG). The principle of UG states that language consists of the infinite use of finite means. Humans can express themselves creatively with a limited yet sufficient amount of vocabulary.

Since creativity is an attribute of human nature, there must be a framework for proper reasoning. At this point of interest, the question of the nature of logic comes to be. A thesis suggested by McKeon (2020) argues that humans reason with inferences they derive from a conversation they are engaging in. Thus, it is argued that humans use semantics derived from the environment in the reasoning process. This idea can be supported in the conclusion of an unrelated experiment by Römer, bein Graben, Huber-Liebl, and Wolff (2022). They argue that generative grammar can be unified with reinforcement learning. They believe they discovered the common ground, thus solving the Chomsky – Skinner debate problem. They argue that language use is shaped by external factors acting as predicates in logical forms in the construction of semantics.

Identifying logic with semantics in its context as predicate logic in language usage is a phenomenon on the level of E-language. Not I-language. Investigating logic at the level of I-language is the aim of this paper. What has been done in the context of the former is the study of “the use of logic.” The aim of this paper, however, is to present the “knowledge of logic.”

## 2.1 Logic in Language

Apart from D-structure and S-structure, another key term in theoretical linguistics is logical form or LF. According to Fox (2002, pp.1), LF is “a syntactic that is interpreted by the semantic component”. Expanding on the given definition, it can be derived that an *a priori* reference is needed before “a syntactic” can be “interpreted by the semantic component.” Thus, the logical form of a sentence is constructed structurally in the mind of the speaker before it reaches the semantics in D-structure of the language faculty. LF can be, and cannot be, analogous to the D-structure or S-structure of a language (Chomsky, 1986). The question of why LF is analogous to D-structure in some cases and analogous to S-structure in other cases is the question addressed in this paper. If LF is independent of D-structure, then the logic faculty is separate from the language faculty.

In *Knowledge of Language*, Chomsky uses the sentence (1986, Location No. 1055)

(i) Who (do) you think saw John?

as how one may use it in English.

In Chinese or Japanese, the structure would be in this order;

(ii) You think who saw John?

According to Chomsky, a suitable table to describe the arrangement of words in (i) and (ii) as being either analogous or not in terms of D-structure, S-structure, and LF would be as follows (1986, Location No. 1170):

**Table 1.** Chomsky’s example.

| <b>Speaker (in language use)</b> | <b>D-structure</b> | <b>S-structure</b> | <b>LF</b> |
|----------------------------------|--------------------|--------------------|-----------|
| English                          | ii                 | i                  | i         |
| Chinese/Japanese                 | ii                 | ii                 | i         |

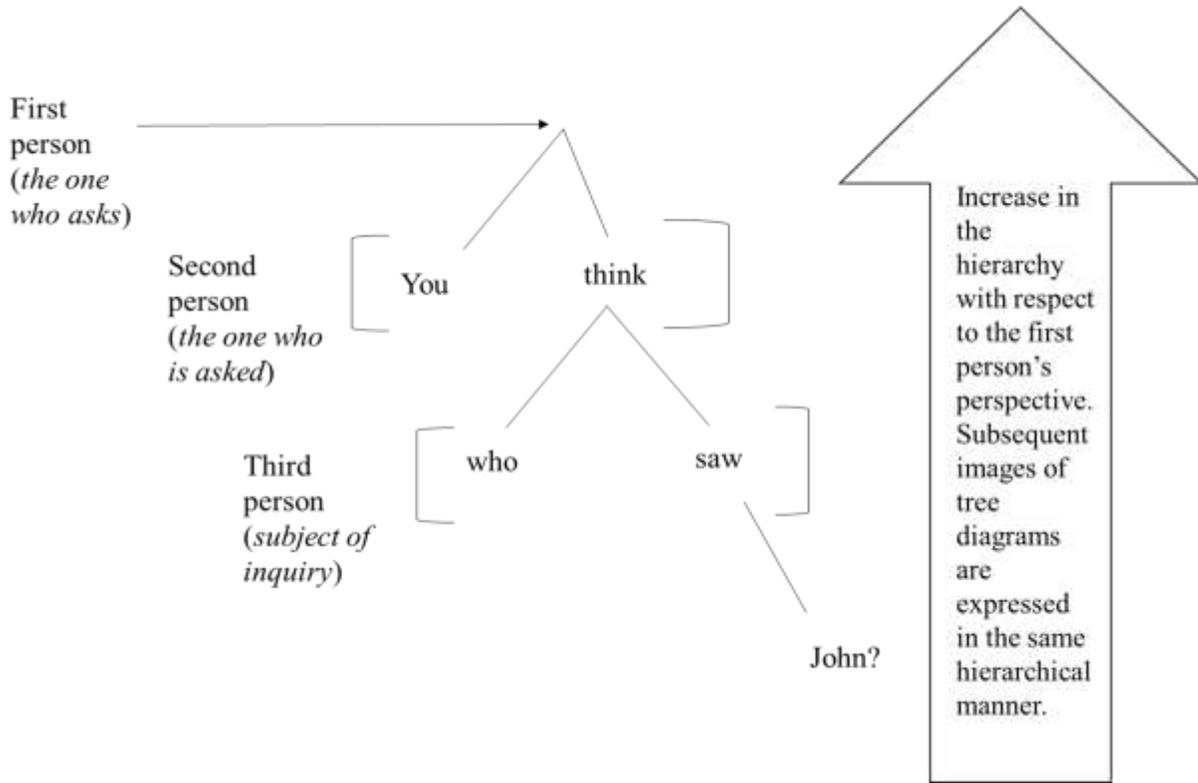
Here it is noted that D-structure and LF do not need to be analogous. Both language speakers would have the same D-structure(s) despite the differences in S-structure(s). In addition to that, they share the same LF. The possibility of such a relation is to be investigated below.

Structure (ii) may be the flow of mental images that forms the meaning in mind, and structure (i) is the logical order that produces the intended meaning.

Given that,

[Who [you think]<sub>NP<sup>1</sup></sub> saw]<sub>NP<sup>2</sup></sub> John?

There are two NPs (noun phrases); “you think” and the other “who saw”. On the S-structure, NP<sup>1</sup> is put in-between NP<sup>2</sup>. However, in the mind of the speaker, it may be represented in this mental image:



**Figure 1.** A mental image of “Who you think saw John?”.

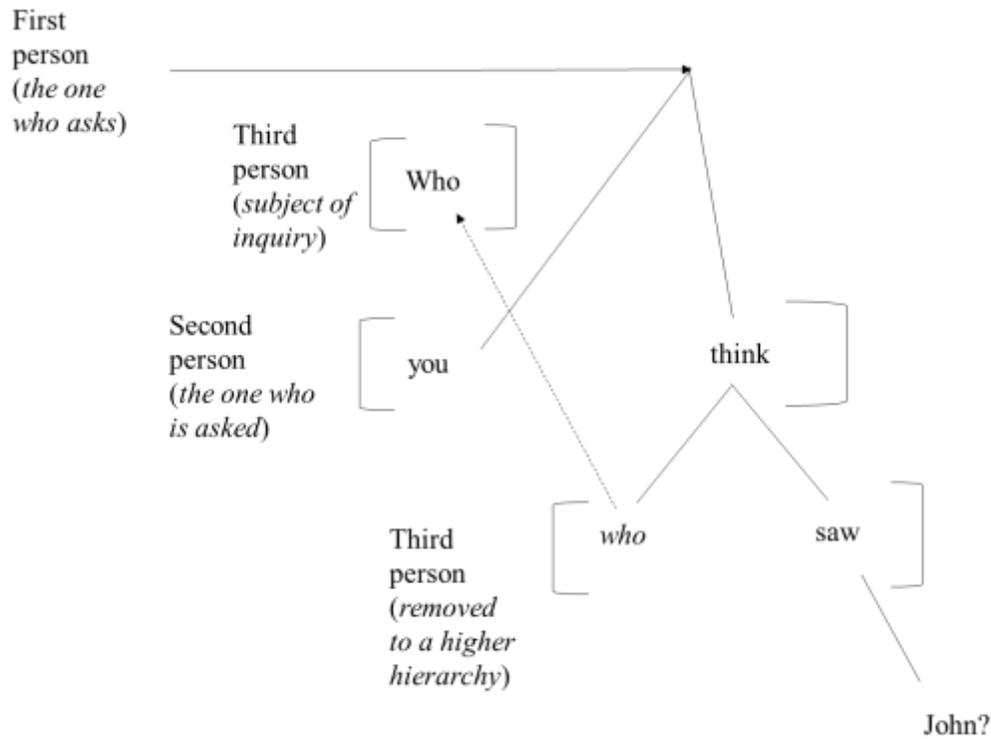
S-structure is the phonetic form of how a language is culturally used. Thus, “Who – you – think – saw – John?” is formed when the speaker expressed the mental image in Figure 1 from his or her mind externally into an acceptable form of the English language. For example, in the Malay language, the same sentence can be translated as follow:

(iii) Siapa awak fikir nampak John?

(iv) Awak fikir siapa nampak John?

To a Malay speaker, both sentences are acceptable, but it is less "awkward" and more "in the flow of the language use in the culture" with structure in (iv). Structure in (iii) is in parallel with structure in (i), and structure in (iv) is in parallel with structure in (ii). Thus, it is taken to be that S-structure is culturally constructed.

If S-structure is dependent on the “flow” of the language in use, which is shaped by social environment and culture (with established cultural grammar rules), then the explanation for the structure of LF is abstract as LF is not embedded in culture, but in human nature. Nonetheless, intuitively, the abstractness of LF can be sketched out as a diagram.

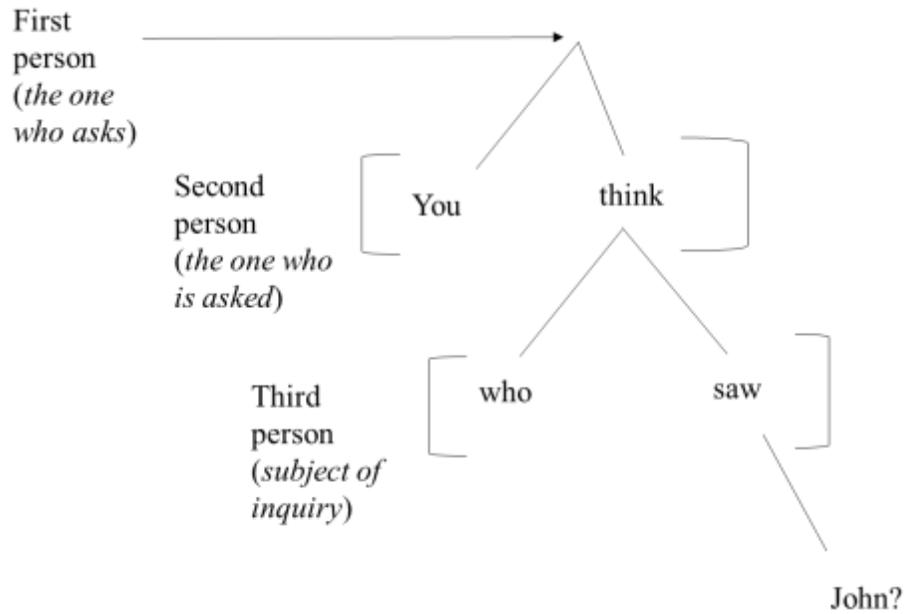


**Figure 2.** The mental image of LF for “Who you think saw John?”.

From the image above, it is noted that “*who*” is promoted to a higher hierarchy into “Who”. To test the viability of this assumption is the rejection of the null hypothesis that states such promotion is unnecessary in preserving intended meaning. A plausible reason is the mind's work to secure the importance of the question “*who*” in the hierarchy of intended meaning.

It is noted that “who you think saw John?” is a question asked by a first-person to a second-person regarding a third-person. The sentence is uttered/constructed in the first person. The main object inquired by the first person is the third person. For this reason, in a hierarchic diagram, to construct the meaning intended by the speaker (first-person), the third person must occupy a higher place than the second person.

If the LF mirrored the D-structure, the intended meaning would be different.



**Figure 3.** If LF mirrors the D-structure for “Who you think saw John?”.

As shown in the diagram above, the third-person (who) is subjected to the second-person's thinking or imagination. Ontologically, the third person will be disqualified as the primary inquiry; hence the intended meaning is lost. If the LF is structured in such a way, the meaning of the sentence is synonymous with a response to the question “you think *someone* saw John?” rather than “*who* you think saw John?”

It shows that there is a difference (in order) between "mental flow of events", which constitutes D-structure, and "logical order of meaning", which constitutes LF. As the former may be associated with the language faculty, the latter is associated with the logic faculty, and its effect is on the language faculty.

## 2.2 Thought Experiment

In this section, a thought experiment will be conducted to observe the changes in the D-structure and LF of a sentence when the context is manipulated while maintaining the S-structure.

The sentence is: “Ali thinks it is going to rain soon”.

The first context of the sentence is the answer to the question, "What does Ali think going to happen soon?"

**Table 2.** Vocabulary table.

| English       | Malay          | Turkish        | Symbol |
|---------------|----------------|----------------|--------|
| Ali           | Ali            | Ali            | A      |
| to think      | (ber)fikir     | düşünmek       | B      |
| going to (be) | akan (berlaku) | (ol)-acak/ecek | C      |
| rain          | hujan          | yağmur         | D      |
| soon          | sebentar lagi  | az sonra       | E      |

**Table 3.** The sentence in the three languages.

| Language | Sentence                                    | S-structure according to symbols in order |
|----------|---|---|
| English  | Ali thinks it is going to rain soon.        | A, B, C, D, E                             |
| Malay    | Ali fikir hujan akan berlaku sebentar lagi. | A, B, D, C, E                             |
| Turkish  | Ali az sonra yağmur olacağını düşünüyor.    | A, E, D, C, B                             |

**Table 4.** The deep structures of the sentences.

| Language | D-structure  | D-structure in symbols  | Symbols in (hierarchical) order |
|----------|--|---|---------------------------------|
| English  | <pre> graph TD     Root["Ali thinks"] --- Node1[" "]     Node1 --- rain["rain"]     Node1 --- Node2["going to (be)"]     Node2 --- soon["soon"]             </pre> | <pre> graph TD     Root["A B"] --- Node1[" "]     Node1 --- D["D"]     Node1 --- Node2["C"]     Node2 --- E["E"]             </pre> | A, B, D, C, E                   |

|                |  |  |                      |
|----------------|--|--|----------------------|
| <p>Malay</p>   |  |  | <p>A, B, D, C, E</p> |
| <p>Turkish</p> |  |  | <p>A, B, D, C, E</p> |

For LF, E (or 'soon') is promoted in the hierarchy. The reason is that "soon" indicates the future time and is subject to Ali's thoughts and intention, which means "going to be rain" is descriptive.

**Table 5.** The logical form of the sentences.

| Language       | LF | LF in symbols | Symbols in (hierarchical) order |
|----------------|----|---------------|---------------------------------|
| <p>English</p> |    |               | <p>A, B, E, D, C</p>            |

|                |  |  |                      |
|----------------|--|--|----------------------|
| <p>Malay</p>   |  |  | <p>A, B, E, D, C</p> |
| <p>Turkish</p> |  |  | <p>A, B, E, D, C</p> |

**Table 6.** The D-structure, S-structure and LF of the sentence “Ali thinks it is going to rain soon” in three different languages.

| Language | D-structure   | S-structure   | LF            |
|----------|---------------|---------------|---------------|
| English  | A, B, D, C, E | A, B, C, D, E | A, B, E, D, C |
| Malay    | A, B, D, C, E | A, B, D, C, E | A, B, E, D, C |
| Turkish  | A, B, D, C, E | A, E, D, C, B | A, B, E, D, C |

The table above shows that each of the three language speakers shares the same D-structure and LF despite the differences in S-structure. On the other hand, D-structure and LF are different for all three language speakers.

The context of "Ali thinks it is going to rain soon" changes when the sentence itself becomes an answer to a different question. Thus, a question like "when does Ali think the rain will happen?" will have the answer “Ali thinks it is going to rain soon” in a different context.

For the new context, the tables for the S-structure and D-structure would be the same, as the sentence remains the same. Nevertheless, the LF would be different. Instead of "soon" being promoted, in the new diagram, it is the word "rain" or D will be promoted. The reason is that "rain" is the intention of the speaker, and "going to (be)" with "soon" are descriptive.

**Table 7.** The logical form of the sentence “Ali thinks it is going to rain soon” in a different context.

| LF | LF in symbols | Symbols in (hierarchical) order |
|----|---------------|---------------------------------|
|    |               | A, B, D, C, E                   |

As already noted, the LF of a sentence in the same context is the same for all three languages.

The sentence then, in the new context, would be:

**Table 8.** The D-structure, S-structure and LF of the sentence “Ali thinks it is going to rain soon” in three different languages in the new context.

| Language | D-structure   | S-structure   | LF            |
|----------|---------------|---------------|---------------|
| English  | A, B, D, C, E | A, B, C, D, E | A, B, D, C, E |
| Malay    | A, B, D, C, E | A, B, D, C, E | A, B, D, C, E |
| Turkish  | A, B, D, C, E | A, E, D, C, B | A, B, D, C, E |

From the table above, it can be seen that the LF is analogous to the D-structure. This contrasts the LF in the earlier context, which is not analogous to the D-structure.

Altogether, the thought experiment can be summarized in Table 9.

**Table 9.** The D-structure, S-structure and LF of the sentence “Ali thinks it is going to rain soon” in three different languages in two different contexts.

| Sentence  | Ali thinks it is going to rain soon       |               |               |  |               |               |
|-----------|---|---------------|---------------|--|---------------|---------------|
| Context   | What does Ali think going to happen soon? |               |               | When does Ali think it is going to rain? |               |               |
| Structure | D-structure                               | S-structure   | LF            | D-structure                              | S-structure   | LF            |
| English   | A, B, D, C, E                             | A, B, C, D, E | A, B, E, D, C | A, B, D, C, E                            | A, B, C, D, E | A, B, D, C, E |
| Malay     | A, B, D, C, E                             | A, B, D, C, E | A, B, E, D, C | A, B, D, C, E                            | A, B, D, C, E | A, B, D, C, E |

|         |                  |                  |                  |                  |                  |                  |
|---------|------------------|------------------|------------------|------------------|------------------|------------------|
| Turkish | A, B, D, C,<br>E | A, E, D, C,<br>B | A, B, E, D,<br>C | A, B, D, C,<br>E | A, E, D, C,<br>B | A, B, D, C,<br>E |
|---------|------------------|------------------|------------------|------------------|------------------|------------------|

### 3 DISCUSSION

It is recorded that the same sentences, despite different contexts, have the same D-structure, despite the different S-structure(s) of different languages. However, the sentence's different context or intended meaning shows a difference in LF. It indicates the idea that LF is not identical to the D-structure. In other words, the logical rules of a semantic (or meaning) are not the same as the flow of events in the mental image. Therefore, the logical rules would be more abstract and nuanced than the mental narratives or mental images of an event. This sublime distinction demands an acknowledgement that there is a unique faculty attributed to logic, which means logical thinking is an innate capability independent from imaginary psychology. This position would refute any suggestions that say external factors that affect our empirical experiences shape the logical rules in the human psyche.

In other words, when images are presented to the mind, they do not become the logical rules. Instead, they become the logical conditions to the logical rules intended in mind. It gives some reflective points:

- (i) Logical sequences (ontological) are not mental imageries but rather 'intuitive'.
- (ii) Within the scope of D-structure and S-structure, the language faculty is separate from the logic faculty.
- (iii) A creature with language faculty but without logic faculty is incapable of using language.

As much as point (iii) makes sense, it follows that, under the law of Universal Grammar (UG), a creature with logic faculty and language faculty would have rich and far more complex logic computations than a creature with a logic faculty but without a language faculty<sup>i</sup>. The reason is that through generative grammar via language, unlimited logical conditions are generated for limited logic rules.

### 4 CONCLUSION

This paper shows that there is the logic faculty, and there is the language faculty, consisting of D-structure and S-structure. To come to this conclusion, a sentence's logical form (LF) is extracted as the intended meaning, and it is contrasted with the deep structure of the language/sentence in use. It is found that, as much as the S-structure and D-structure of a sentence can be constant, LF can be manipulated when the intended meaning is adjusted. It shows that the logic faculty, in this sense, is more subtle than the language faculty. However, the subtleness of the logic faculty is contrasted with the use of the language faculty. In other words, the subtleness of the logic faculty displayed its brilliancy when language is used with an intended meaning. The "intention" suggests

that logic works intuitively, not alone, but with logical conditions that can be found in language use and environment.

If the theory suggested is true, then in the psychology of education, it can be assumed that ‘reading’ is more effective for children and adult’s cognitive development/exercise than for them to be trained with pattern recognitions such as abstract puzzles and games – although such games are still beneficial for human cognitive exercises.

## 5 ENDNOTES

- i. According to James McGilvray (2013, pp. 37), "(f)or Chomsky, if there is anything that distinguishes the minds of humans from those of (say) the higher apes, it is not reason, but language, for language [...] offers the means for us to think and reason [...]”.

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