How is Language Linked to Other Cognitive Domains? A Brief Review

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1. Introduction

The processing of language involves linguistic and non-linguistic components. In order to have a better understanding of how language is acquired, we need to look into the relationships between language and other domains of cognition. There is no lack of studies in favor of their close connection. The configuration and manipulation of language input are supported by memory in the brain, particularly working memory (Baddely, 1986; Ecker, Oberauer, & Lewandowsky, 2014). The structure and perception of music and language seem to be closely linked, sharing similar mental representations (Koelsch, et al., 2004; Palmer & Jungers, 2001; Palmer & Kelly, 1992). Language influences spatial thinking (Levinson, 2003), and children's acquisition of spatial language is affected by both pre-linguistic concepts about space and the specific properties of the language to which children are exposed (Ji, Hendriks, & Hickmann, 2011). This paper reviews the literatures that examined this issue in terms of how gestures and mathematical ability are linked to language competence, points to their limitations, and suggests future research directions.

2. The basic word order

Most human languages have basic sentence constituents of the subject (S), the object (O), and the verb (V), but they vary widely in how to order these elements. For example, the basic order of the Japanese language is SOV and that of English is SVO. Among possible six word orders, SOV and SVO predominate (47.1 % and 41.2%, respectively) followed by VSO (8.0%) (Dryer, 2005). Whaley (1997) also reported the similar pattern of predominant word orders with 45% being SOV and 42% being SVO.

Furthermore, Givon (1979) and Newmeyer (2000) argue that SOV is the most basic and default word order and that other word orders have descended from SOV over time. Recently Goldin-Meadow, So, Ozyurek, and Mylander (2008) confirmed the preference for the SOV order in their psycholinguistic experiments. They asked speakers of English, Spanish, Chinese, and Turkish to describe transitive and intransitive events nonverbally, i.e., in gestures. The participants generally used their gesturing orders in SOV, irrespective of the languages they used verbally.

Then a new question arises; why is the SVO order (shown in the English word order) as prevalent as the SOV? What makes people choose SVO? Jackendoff (2002: 247-251) supports the preference for subjects to be placed at the beginning of the sentence by terming this tendency as the ‘Agent First’ principle. This trend is remarkably noticeable along with another principle of ‘Focus Last’ in language learners without full grammar like second language learners (Klein & Perdue, 1997). This idea does not, however, explain the distinction between SOV and SVO.

3. A shift to the SVO order

There have been two types of experimental research which attempted to address the above issue. The first type of research was conducted by Gibson, Piantadosi, Brink, Bergen, Lim, and Saxe (2013) and Hall, Mayberry, and Ferreira (2013).

Gibson et al. (2013) asked participants to watch brief animations of events, verbally describe the events, and then gesture them. They used two types of events. One was a nonreversible event described by sentences like "The boy throws the guitar". Since this type of event has an animated subject (boy) and an inanimate object (guitar), it does not necessarily cause a misunderstanding if the subject and the object are reversed ("The guitar throws the boy" does not make sense in the real world). The other was a reversible event in which the subject and the object can be reversed but leads to confusion about the meaning ("The boy throws the girl" and "The girl throws the boy" have different meanings).

Participants were thirty-eight native speakers of English, 23 native speakers of Japanese, and 24 speakers of Korean. The basic word order of English is SVO, and that of Japanese and Korean is SOV. When they describe nonreversible events in gestures, speakers of English, Japanese, and Korean primarily used the SOV order. In order to describe reversible events, however, they made a shift to SVO, although Japanese and Korean speakers showed this shift noticeably only when they dealt with complex events including embedded clauses. Gibson et al. (2013) concluded that the choice of word order (OV or VO) depends on the easiness of meaning recoverability and that SVO is preferred when both the subject (the agent) and the object (the patient) are animated or human to avoid potential misunderstandings.

In a similar vein, Hall et al. (2013) tested monolingual native speakers of

English to examine how they express nonreversible and reversible events through gestures. The results showed they increased the use of SVO when reversible events were described, replicating Gibson et al. (2013). They interpreted the outcome as the role conflict hypothesis whereby there is confusion when a patient (object) is followed by an action (verb) in the SOV order.

The other approach was taken by Schouwstra and de Swart (2014). They focused on the effect of the verb meaning on the position of verbs and objects in nonreversible events, that is, the events with animated subjects and inanimate objects. The above two previous experimental studies used both reversible and nonreversible events and found that people tend to favor the SVO order when they describe reversible events, i.e., the events in which both subjects and objects are animated. Schouwstra and de Swart (2014) hypothesized that even when people deal with nonreversible events, they might choose SVO, depending on the meaning of the verb in the messages.

In their experiments two kinds of verbs were included: extensional and intensional verbs. Extensional verbs are motion verbs like *throw* and *carry*, and involve some action through space. Intensional verbs do not contain direct action against objects such as *hear* and *think*. Participants were speakers of Dutch (an SVO language) and Turkish (an SOV language). They were shown pictures of events on a computer screen, and asked to convey their meanings by using only gestures and without talking. After the video recordings were coded for gesturing order by two independent coders, it was found that for intensional events (e.g., "Pirate hears guitar") participants used the SVO order more often than the SOV order, while for extensional events (e.g., "Pirate throws guitar") they used more SOV than SVO, regardless of participants' native languages. Schouwstra and de Swart (2014) interpreted their results as supporting the view that intensional verbs make their objects more abstract and more dependent on the meaning of the verbs, which in turn get people to describe objects after the verb (SVO), instead of objects followed by verbs (SOV). They conclude that the meaning of the verb plays a crucial role in ordering events independently of language and suggests that semantics guides syntactic formation in the early stages of language learning.

The above studies about language and gesture provide new insights and pose interesting questions as to how language and gesture are actually linked. Their results imply that gesture and language are separated so far and vastly that the word order of native languages does not influence the order in gesture. This notion indicates that gesture is language-independently cognitive in nature, located deeper in our mind. When we attempt to obtain some clues to language acquisition from the examination of gesture, it seems possible to address the issues regarding second language learning. It is often argued that second language learners tend to resort to semantic and pragmatic properties when they produce and comprehend utterances spoken in their second language due largely to their limited capacities to utilize syntactic properties (Klein & Perdue, 1997).

4. Cross-domain structural priming

How are language and mathematics related, if any? It seems that linguistic and mathematical expressions share similar features: their interpretations are based on recursive structures which are composed of compositional elements.

The following examples (cited from Scheepers & Sturt; 2014) show that 1a. and 2a. have a right branching structure, while 1b. and 2b. possess a left branching structure. The correct responses are achieved by the application of operator precedence rules in the mathematical equations (i.e. multiplication and division take precedence over addition and subtraction) and of plausibility constraints in the linguistic expressions (e.g., regarding 2a, "a coffee dealer who is bankrupt" is more plausible than "a dealer of bankrupt coffee", and 2b prefers the interpretation of "a dealer of organic coffee" over "a coffee dealer who is organic").

1a. 25 - 4 x 3

1b. 25 x 4 + 3

2a. bankrupt coffee dealer

2b. organic coffee dealer

Scheepers & Sturt (2014) investigated the nature of shared representation of language and mathematics through the use of the structural priming paradigm. Structural priming is a tendency to process a current sentence ("target") fast because of its structural similarity to a previously experienced ("prime") sentence (Pickering & Ferreira, 2008).

In their first experiment participants (university students who are native English speakers) were asked to solve each mathematical equation by writing down the correct result, and to provide a plausibility rating for each linguistic expression (i.e., an adjective-noun-noun compound) on the 1-5 scale. In their second experiment the task was reversed whereby participants first had to judge the plausibility of linguistic expressions and then solve a mathematical equation. In other words, experiments one and two examined priming from mathematics to language and from language to mathematics, respectively.

The results were as follows: in experiment one left-branching target expressions like 2b. received significantly higher plausible ratings after the primes of left-branching equations such as 1b., while the priming effects for right-branching target expressions (e.g., 2a) were marginally reliable. Similarly, in experiment two right-branching target equations (e.g., 1a) were significantly more likely to be solved correctly after the primes of right-branching linguistic expressions (e.g., 2a) and left-branching target equations (e.g., 1b) tended to receive higher numbers of correct answers after left-branching linguistic primes.

Their conclusion is that there is structural priming between language and mathematics and that this cross-domain structural priming is bidirectional, presumably because language and mathematics share deep, abstract structural representations in our mind.

Regarding the issue of right-branching or left-branching structure, English and Japanese show a sharp contrast in such structure as verb phrases. English is a head-initial language with a right-branching structure, while Japanese is a head-final language with a left-branching structure (Tsujimura, 2014). Scheepers & Sturt (2014) mentioned that participants generally rated right-branching phrases more favorably than left-branching phrases, a tendency they called a right-branching preference. However, they did not attribute this trend to a characteristic of native speakers of English, nor did they take into account potential cross-linguistic differences. It remains to be investigated in further research whether the same results would occur should native speakers whose language prefers left-branching phrases like the Japanese language participate in such experiments.

5. Conclusion

The above research is well in line with "the emergentist thesis for language", defined as follows:

> The phenomena of language are best explained by reference to more basic non-linguistic (i.e., 'non-grammatical') factors and their interaction — physiology, perception, processing, working memory, pragmatics, social interaction, properties of the input, the learning mechanisms, and so on (O'Grady, 2008).

Studies suggesting the close relationships between language and other cognitive domains argue that there must be abstract, general representations shared among different cognitive domains. Then, what is the nature of these abstract representations? What degree of abstraction is involved in these representations? Linguistic words possess their own specific meanings, but numbers have nothing other than mathematical amounts. It remains unclear what kinds of abstraction people can gain from these very different tokens.

Nonetheless, language learning is a very complex phenomenon involving linguistic and other cognitive properties intermingling. Further empirical and psycholinguistic research is, therefore, needed to explore the nature of the general mechanism of cognition and learning and establish the process whereby language learning takes place affected by other cognitive factors.

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