The number of times a motion repeats influences sentence processing.

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Abstract

We investigated how the semantic properties of verbs influence the way in which language users process sentences and how well they remember the verb. In particular, our study focused on the frequency of motion repetition, that is, how many times actions generally repeat in a row. The experimental sentences contained action verbs, such as *sneezing*, *knocking on a door*, *clapping*, and *bouncing a ball*. Half of the target sentences contained verbs that refer to actions that generally repeat once or twice in a row in the real world (determined by norming), such as *sneezing*, *coughing*, and *knocking on a door*. The other half contained verbs referring to actions that typically repeat many times in row, such as *hiccupping*, *clapping*, and *bouncing a ball*. Native Korean speakers performed a sensicality judgment task where they decided whether given Korean sentences were sensical or not. We also tested how well participants remember the verbs in target sentences. The results show an effect of action repetition frequency: Participants judged sentences with low repetition frequency verbs more accurately than sentences containing high repetition frequency verbs. We propose that verbs describing multiple repetitions may place a greater processing load than verbs involving fewer repetitions.

Keywords: lexical semantics, action repetition frequency, sentence processing, sensicality judgment, memory retention

Introduction

Understanding language requires a number of different processes. As part of language use, comprehenders need to retrieve the meanings of individual words from their mental lexicon (Federmeier & Kutas, 1999; Ferreira & Yoshita, 2003; Pinker, 1994; Rappaport, Levin, & Laughren, 1993; Slevc, 2011; Ullman, 2001; Ullman et al., 1997). They also need to understand the structural relationships between phrases to compute the intended meaning using syntactic representations (Chomsky, 1995; Ferreira & Yoshita, 2003; Gibson, 1998; Rappaport, Levin, & Laughren, 1993; Slevc, 2011; Ullman, 2001). Our focus is on the first component, in particular the lexical semantics of words.

Research has shown that comprehenders' linguistic behaviors are sensitive to words' lexical semantics. For example, Fecica and O'Neill (2010) showed that four to six year-olds' comprehension is influenced by the speed of a movement conveyed by verbs (e.g. *walking* vs. *driving*). When children listened to a story where the protagonist was described as *walking* to a place, their processing of subsequently related sentences was slower than when the character was described as being *driven* to the place. Fecica and O'Neill concluded that children, like adults, build mental representations of the actions based on their world knowledge, and their mental representations influence how they process subsequent information. See also Martin & Chao (2001) for related work.

Lindsay et al. (2013) conducted an eye-tracking with adults on how the speed of an action conveyed by the verb (e.g. *mope* vs. *sprint*) influences what comprehenders pay attention to in a visual scene and how much time they spend scanning the scene. Participants spent more time looking along the path when listening to sentences containing slow verbs (e.g. The hiker will *mope* along the trail to the cottage) compared to fast verbs (e.g. The hiker will *sprint* along the trail to the cottage). Participants also looked at the goal earlier when listening to sentences containing fast verbs. Related work by Matlock (2004) found that people spent more time reading sentences depicting a longer physical distance ('The road runs through the valley') compared to a shorter distance ('The cord runs along the wall').

Further data regarding effects of motion speed on language processing comes from Yao and Scheepers (2011) and Stites, Luke, and Christianson (2013). Yao and Scheepers investigated whether comprehenders' reading rates would differ depending on how fast the protagonist was implied to be speaking. In the 'fast' condition, readers were given stories in which the protagonist was implied to be speaking at a fast rate (e.g. a boy who is nervous and shaking). In the 'slow' condition, participants were given stories where the character was implied to be speaking at a slow rate (e.g. an old man on his deathbed). The results showed a significant context effect on reading rates: Participants read direct quotations faster when the protagonist was implied to be speaking fast than when the protagonist was implied to be speaking slowly.

As a whole, these studies demonstrate that words' semantic information influences the behaviors of language comprehenders, such as visual scanning of a scene, reading speed, and comprehension rates. Verb semantics can differ in many aspects: (i) action-related verbs vs. abstract verbs (e.g. *to scrub* vs. *to trouble*, Innocenti et al., 2014); (ii) bodily orientation (e.g. face-related verbs vs. non-face-related verbs, *to talk* vs. *to walk*, e.g. Pulvermüller et al., 2001); and (iii) speed of motion (e.g. *to walk* vs. *to run*, e.g. Fecica & O'Neill, 2010; Lindsay et al., 2013).

Another aspect of verb semantics has to do with the frequency of motion repetition. We use the term 'frequency

of repetition' to refer to the number of times an action generally repeats in a row. In the world, we observe and perform actions all the time. We knock on doors, clap hands, bounce balls, or watch others do these things. These actions repeat in succession, but some repeat more frequently than others. E.g., *clapping* is prototypically thought to involve several 'hand claps', whereas the act of *ringing a door bell* does not involve as many ringing hand motions. Similarly, while people generally s*neeze* once or twice in a row, they *hiccup* multiple times in a row.

Though there are ample studies that reveal both behavioural and neurological consequences of different aspects of verb semantics, we are not aware of any prior research on how frequency of motion repetitions could influence language processing. To address this, we tested whether verbs' repetition frequencies influence comprehenders' sensicality judgments and their ability to recall verb information. The study was done in Korean.

Method

Norming Study

A norming study was done to see how many times Korean speakers typically think certain actions generally take place in a row. Forty native Korean speakers participated in a web-based survey (done with Qualtrics software, Qualtrics 2010). Participants were given 36 action verbs and were asked to indicate (in an open-ended task) how many times each of the actions generally takes place in a row. For example, 'On average, how many times would one blow his/her nose in a row?' The norming study was in Korean.

Based on the norming results, we identified a set of 24 verbs that we divided into two frequency conditions: (i) a High Expected Frequency condition and (ii) a Low Expected Frequency condition. Each condition included 12 target actions. Some example actions in the High Expected Frequency condition are: 박수를 치다, 딸국질을 하다. 공을 뛍기다, 손을 흔들다 (English: *clapping*, *hiccupping*, *bouncing a ball*, and *waving hands*[1]). In the High Expected Frequency condition, the average number of repetitions per action (how many times the action takes place in a row) was 10.7 times (ranging from 3.6 times to 36 times, SD = 6.66)[2]. Some example actions in the Low Expected Frequency condition are: 재채기를 하다, 기침을 하다, 초인종을 누르다, 노크를 하다 (English: *sneezing*, *coughing*, *ringing a door bell*, and *knocking on a door*). The average number of repetitions per action in the Low Expected Frequency condition was 2.2 (ranging from 1.5 times to 2.9 times, SD = .8).

Main Experiment

Participants A new group of 32 native Korean speakers recruited in Korea participated in the main experiment. They were paid $10 for their participation.

Stimuli Participants took part in three tasks in this order: (i) a sensicality judgment task, (ii) a distractor math task, and (iii) a probe-verb recognition task. The sensicality judgment task included 24 target and 60 filler sentences written in Korean. Every target sentence included a proper name as the grammatical subject, an action verb (in the past tense), and a number adverbial (e.g. 규진이가 기침을 두 번 했다. Kyujin twice coughed '*Kyujin coughed twice*'). See Table 1 for more example sentences. The action verbs used in the target sentences were either Expected High Frequency or Expected Low Frequency verbs, as determined in the initial norming study reported above. Thus, *verbs' inherent (or expected) frequency* (i.e. whether a verb typically has a high or low frequency of repetition) served as one of two variables in the experiment. Twelve target sentences contained actions that generally repeat multiple times in row, and another 12 sentences contained actions that usually repeat once or twice in a row. The number of Korean characters in the target sentences ranged from 12.8 to 14.5. The average number of characters in the High Expected Frequency condition was 14. The average number of characters in the Low Expected Frequency condition was 13.

In addition to *verbs' expected frequency*, we manipulated the *number adverbial* present in the sentence. Including these two factors made it possible to test whether participants' performance is influenced by verb inherent semantics, explicit number expressions, or their interaction.

The number adverbial had two levels: Low Frequency (e.g. *once* or *twice*) and High Frequency (*five times* or *six times*). In the verb-adverb frequency *match* condition, the target verbs were used with a number adverbial that matched their expected frequency. For example, *sneezing* was used with the adverbial *once* or *twice* in the match condition (e.g. 규진이가 기침을 한 번/두 번 했다 *Kyujin coughed once/twice*). In this item, the expected verb frequency and the adverbial matched in number because sneezing generally repeats once or twice in a row. In the same way, the verb *clapping* was used with *five time*s or *six times* to match its expected frequency (e.g. 규진이가 손벽을 다섯 번/여섯 번 쳤다 *Kyujin clapped five/six times*). In the verb-adverb frequency *mismatch* condition, the verbs were used with an adverbial that mismatched their expected frequency. For example, *coughing*, which generally repeats once or twice in a row, was used with *five/six times* (e.g. *Kyujin coughed five/six times)*, and *clapping* was used with *once/twice* (e.g. *Kyujin clapped once/twice*). This two by two design yielded the four conditions presented in Table 1.

[1] Some of the target verb phrases included the verb itself combined with 'do' (e.g. 재채기-를 (*sneeze*-object marker) + 하다 (to do). However, other verb phrases included a direct object (e.g. 공을 뛍기다 (bouncing a ball); 문을 두드리다 (knocking on a door)).

[2] Three verbs in the High Expected Frequency group had average frequencies higher than the other actions in that group: 윗몸일으키기를 하다, 팔굽혀펴기를 하다, 물장구를 치다 *doing sit-ups, doing push-ups, paddling one's feet in water* (average frequencies 36, 19, 19, respectively). The average repetition of the High Expected Frequency without these three items is 5.6 (S.D. 2.27). Thus, even without these verbs, High Frequency verbs are higher than Low Frequency verbs.

Table 1. Sample targets in each condition

condition	sample target sentence
Expected High-Adverb High	아람이가 박수를 다섯 번 쳤다. Aaram clapped five times.
Expected High-Adverb Low	아람이가 박수를 한 번 쳤다. Aaram clapped once.
Expected Low-Adverb High	규진이가 기침을 여섯 번 했다. Kyujin coughed six times.
Expected Low-Adverb Low	규진이가 기침을 두 번 했다. Kyujin coughed twice.

To summarize, there were 24 target verbs: 12 verbs whose expected repetition frequency was low and 12 verbs whose expected repetition frequency was high. Of the 12 verbs in the Low Expected Frequency condition, half (6) were paired with a number adverb that matched their expected low frequency. The other six verbs in this condition were paired with a number adverb that mismatched their expected low frequency. This design was reserved for the 12 verbs in the High Expected Frequency condition.

Sensicality Judgment Task The sensicality judgment task was conducted using Paradigm software (Perception Research Systems). The sentences were presented on a computer screen one at a time. Participants were instructed to read the sentences as they would naturally and to decide at the end of each sentence whether it was a sensical or meaningful expression in Korean. Participants pressed the 'J' key on the keyboard for 'yes' (makes sense) and 'F' key for 'no' (does not make sense). We used the sensicality judgment paradigm because identifying the sensicality of sentences has been shown to be a sensitive measure of conceptual processing and interpretation of linguistic items (e.g. Bambini & Schumacher, 2012; Klein & Murphy, 2001; Murphy, 1991). All target sentences were sensical sentences, requiring a 'yes' response. Some fillers included nonsensical sentences, such as 준수가 김치찌개에 건물을 탔다 '*Joonsu put a building in a kimchi stew*'). The number of expected sensical and nonsensical sentences over the course of the full experiment (targets and fillers) were balanced. All participants completed this task within 20 minutes.

Distractor Task After finishing all the targets and fillers in the sensicality judgment task, participants completed a calculation test as a distractor task. They were given 14 arithmetic problems to solve. The time allotted for the distracter task was three minutes and thirty seconds.

Probe-verb Recognition Task After the distractor task, participants completed a probe-verb recognition task. On the same computer, participants saw 48 verbs, 24 from all target sentences and 24 from filler sentences. The verbs were presented as infinitivals (ex.1), without the number adverbials. Participants were asked to indicate whether they had seen the expressions in the previous sensicality judgment task. They were instructed to press the 'J' key for 'yes' and 'F' key for 'no'. All target verbs proved required a 'Yes' response. Fourteen out the 24 filler verbs required a 'No' response. Therefore, 34 probe verbs required a 'yes' response (24 from the targets and 10 from fillers), and 14 probe verbs required a 'no' response.

(1) Sample target verbs in the probe-verb recognition task
a. 노크를 하다 to knock on the door
b. 기침을 하다 to cough
c. 딸국질을 하다 to hiccup
d. 박수를 치다 to clap

Predictions

It was predicted that participants' sensicality judgment and recognition of verbs would differ depending on the inherent frequency semantics that the verbs express. Specifically, we predicted that *low inherent repetition* frequency would result in easier processing and therefore yield higher sensicality judgment accuracy. Although all target sentences are sensical, we speculated that people would be more accurate judging the sensicality of the sentences containing actions which generally repeat once or twice in a row (e.g. *coughing*, *sneezing*). In contrast, participants' judgment accuracy might decrease when the sentences are about actions that repeat multiple times in a row (e.g. *hiccupping*, *clapping*). This hypothesis was formulated on the basis of the evidence suggesting that physical information depicted in sentences influences linguistic processing. E.g., comprehenders take longer to read sentences depicting a long distance than reading sentences depicting a short distance (Matlock, 2004). Additionally, speed of an action has also been shown to influence linguistic behaviors. Both child and adult comprehenders spend more time reading or understanding sentences if the verb in the sentence refers to a slow movement (e.g. *to walk*) than if the verb refers to a fast movement (e.g. *to run*). Furthermore, Moody and Gennari (2010) showed that brain activation levels differ depending on the degree of physical effort implied by nouns. They found higher activation in the sensory-motor regions when people read sentences describing greater physical effort (e.g. 'The delivery man is pushing the piano.') than when they read sentences describing relatively less physical effort (e.g. 'The delivery man is pushing the chair.').

We predicted that processing sentences with low motion frequency verbs might involve a lighter processing load than processing sentences that contain high motion frequency verbs. Participants' sensicality judgement and verb recognition accuracy might be better for the sentences with low-repetition verbs than high-repetition verbs because processing high-repetition verbs might place more of a burden in the processing system than low-repetition verbs. (For related work on off-line measures reflecting processing load, see Hofmeister et al. (2013) on syntactic complexity and acceptability judgments.)

Concerning the number adverbials, we predicted that the explicit number expression might interact with the verb's expected frequency semantics. Specifically, we expected

higher sensicality accuracy when the number adverbial matches the verb's expected frequency (e.g. *coughing* occurs generally *once* or *twice* in a row, not *five/six times*). When the explicit number expression clashes with the expected frequency of the action (e.g. *clapping* just *once* or *twice* when it is expected to repeat multiple times), the sensicality judgment accuracy was expected to be low. Response accuracy is a common indicator of comprehension difficulty (Mitchell et al., 2010). Low response accuracy is often an indicator of greater processing load.

Results

We measured how accurately people responded that the target sentences were sensical (response accuracy), and how accurately they recalled having seen the verbs (recognition accuracy)[3].

Sensicality Judgment Accuracy Results

As Figure 1 shows, the sensicality judgment accuracy rates were high overall (above 90% in all conditions). The high accuracy rates confirm that the target sentences were indeed sensical and sounded natural to participants. Though participants were highly accurate, there still were distinct patterns between the frequency conditions. The accuracy rates of the two conditions in the Expected High Frequency were in the low 90's (91% and 90%), and the accuracy rates of the two conditions in the Expected Low Frequency were in the high 90's (98% each). The high and low number adverbials (*once/twice* vs. *five/six times*) did not seem to influence the accuracy patterns.

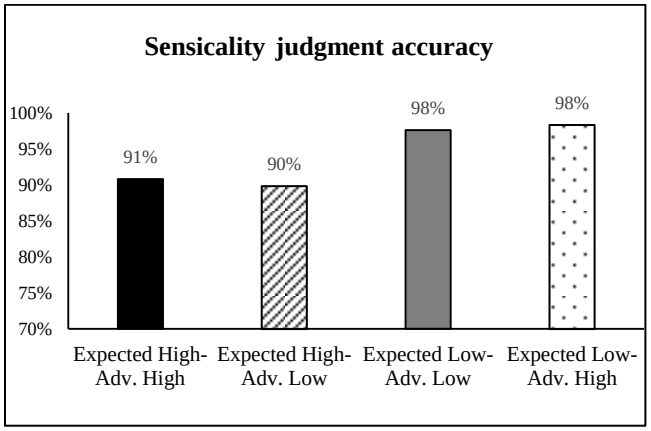

Figure 1. Sensicality judgment accuracy rates

Repeated measures ANOVAs were conducted on participants' accuracy responses to test the effects of (i) *verbs' inherent frequency*, (ii) *number adverbial*, and (iii) their interaction. A significant main effect of *verbs' inherent frequency* was found on the sensicality judgment accuracy; $F_1(1, 31) = 37.933$, $p < .0001$, $F_2(1, 44) = 2.431$, $p = .126$. This effect is significant in the by-subjects analysis but not in the by-items analysis.[4]

On the whole, participants responded more accurately to sentences containing inherently low frequency actions, which generally repeat once or twice in a row (e.g. *coughing*, *sneezing*), than sentences containing inherently high frequency actions that typically repeat multiple times in a row (e.g. *clapping*, *hiccupping*). There was no main effect of *number adverbial* on the sensicality judgment accuracy; $F_1(1, 31) = .104$, $p = .749$, $F_2(1, 44) = .000$, $p = .988$. Sensicality judgments did not differ whether the number adverbial used in the sentence matched or mismatched the verb's expected frequency. There was also no interaction between *verbs' inherent frequency* and the match/mismatch status of the *number adverbial*; $F_1(1, 31) = .008$, $p = .929$, $F_2(1, 44) = .006$, $p = .937$.

Probe-verb Recognition Accuracy Results

Figure 2 shows the percentage of correct recognition of the verbs. Verb recognition accuracy across the four conditions ranged from 64% to 77%. The lowest accuracy rate of 64% was in the Expected High-Adverb High condition where the verb's repetition frequency and the adverbial were both high. This indicates that participants found it difficult to correctly recognize the high repetition verbs which they had initially seen with a matching high adverbial (e.g. *Aaram clapped five times*). The accuracy rates from the other three conditions were higher (i.e. 76% and 77%).

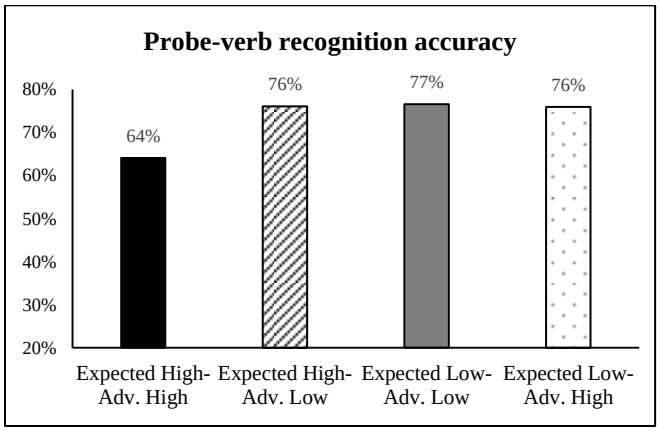

Figure 2. Probe-verb recognition accuracy rates

As in the sensicality judgment accuracy, a repeated measures ANOVA test revealed a significant main effect of

[3] The software also recorded response times, but RT patterns did not reach significance (*p*s > .071).

[4] The *item* analyses (F_2) were conducted using Two-Way 'Between Items' ANOVAs with *verbs' inherent frequency* and *number adverbial* as two factors. This was done because low and high frequency verbs are different lexical items (e.g. *coughing* and *hiccupping*), so it was not possible to rotate a given verb through all four conditions. That is, half of the verbs (12 out of 24) were in the 'Expected-High' condition, and the other half were in the 'Expected-Low' condition. The subjects analyses (F_1) used within-subjects ANOVAs.

verbs' inherent frequency on verb recognition accuracy; $F_1(1, 31) = 4.399$, $p = .044$, $F_2(1, 44) = 2.720$, $p = .106$. The recall accuracy in the two Expected Low Frequency conditions is higher than that of the Expected High Frequency conditions. That is, remembering verbs that refer to inherently low repetition actions (e.g. *sneezing*, *coughing*) is easier than remembering verbs that refer to inherently high repetition actions (e.g. *hiccupping*, *clapping*). There was also a significant main effect of *number adverbial* on verb recognition; $F_1(1, 31) = 5.246$, $p = .029$, $F_2(1, 44) = 2.907$, $p = .095$. Participants recognized the verbs better when they appeared with low frequency adverbials (*once/twice*) than high frequency adverbials (*five/six times*). The interaction between *verbs' inherent frequency* and *number adverbial* on verb recognition was not significant; $F_1(1, 31) = 2.828$, $p = .103$, $F_2(1, 44) = 2.278$, $p = .138$.

Although the interaction did not reach significance, the p-values were relatively low. We thus conducted planned comparisons comparing the Expected High-Adverb High condition to the Expected High-Adverb Low condition (the left two bars in Figure 2). We also compared the Expected Low-Adverb Low condition to the Expected Low-Adverb High condition (the right two bars in Figure 2). Verb recognition accuracy in the Expected High-Adverb High condition is significantly lower than that of Expected High-Adverb Low condition; $t_1(31) = -2.623$, $p = .013$; $t_2(11) = -2.733$, $p = .019$. That is, when the expected high frequency verbs (e.g. *clapping*, *bouncing a ball*) appeared with their matching high frequency adverbial (*five/six times*), verb recognition accuracy decreased (as the far left bar in Figure 2 shows) than when the expected high frequency verbs occurred with low adverbial. This shows that when the adverbial was of low frequency (although the verb was a high frequency action), participants' recall of the verbs improved. The number adverbial did not change the verb recall behavior in the Expected Low conditions.

Discussion

The present study explored the effect of a semantic property of action verbs on sentence processing. In particular, we wanted to see whether the number of times an action typically repeats in a row would influence the way in which comprehenders process sentences and recall sentential information. We manipulated *action-verbs' expected repetition frequency* as determined by a norming study. We tested Expected High Frequency verbs, referring to actions which typically repeat multiple times is a row (e.g. *hiccupping*, *clapping*, *bouncing a ball*). We also tested Expected Low Frequency verbs denoting actions which generally repeat once or twice in a row (e.g. *sneezing*, *coughing*, *ringing a doorbell*).

In addition to *verbs' inherent frequency*, we also manipulated the *number adverbial* referring to the specific frequency expression used in the sentence: (i) low frequency adverbials (i.e. *once* and *twice*) and (ii) high frequency adverbials (i.e. *five times* and *six times*). The target action verbs appeared in the sentence either with a number adverbial that matched its expected frequency (e.g. *ringing a door bell once/twice; clapping five/six times*) or that did not match its expected frequency (e.g. *ringing a door bell five/six times; clapping once/twice*). The adverbials were included so as to test whether the effect of motion repetition on sentence processing is modulated by the specific number expressions used in the sentence.

It was hypothesized that participants would be better at processing sentences that contain verbs of inherently fewer movement repetitions than verbs of many repetitions (e.g. *sneezing* over *hiccupping*). We predicted that the mental representations involved in the depiction of low repetition actions would be reduced compared to the mental representations involved in high repetition actions. We predicted that sentence processing would be easier when the verb's expected frequency matches the number adverbial than when they mismatch. Participants completed a sentence sensicality judgment task and a probe-verb recognition task.

The results from both tasks revealed a significant effect of *verbs' inherent frequency*. In the sensicality judgment task, people accepted sentences containing low frequency actions more accurately (e.g. *Kyujin coughed twice/six times*) compared to sentences containing high frequency actions (e.g. *Kyujin hiccupped twice/six times*). Further, verbs referring to low frequency actions were remembered better than verbs referring to high frequency actions.

Strikingly, there was no significant effect of whether or not the number adverbial matches or mismatches the verb's typical frequency. Participants' sensicality judgment did not differ between *Kyujin coughed six times* and *Kyujin coughed twice* or *Aaram clapped five times* and *Aaram clapped once*. We also found no interaction between *verbs' inherent frequency* and *number adverbial*s. The lack of the match/mismatch effect may indicate the importance of verb semantics in overall sentence comprehension. The verb might have played a central role in individuals' comprehension of the sentence, and the number adverbial could have been supplementary to the overall meaning. The verb itself might have provided strong enough of a cue for building the mental representation of the action described.

Let us consider a possible alternative interpretation for our results. Could it be that accuracy rates were lower for high frequency actions because such actions usually do not appear with number adverbials (i.e. adverbials seem 'odd')? We think this is unlikely for two main reasons. First, the fact that there was no significant effect of number adverbial speaks against the oddness explanation. If participants found the sentences in which high frequency actions occur with number adverbials unnatural, then those sentences should have been judged non-sensical. However, the sentences of high frequency actions were still judged sensical 90% of the time. Second, the literature on sentence processing and memory speaks also against this oddness explanation. Comprehenders tend to remember expressions that are noticeable. If participants found those sentences odd in which high frequency actions were described with specific number adverbials, this unusual expression might have

stood out, and the high frequency action-verbs should have been recognized better than the low frequency verbs.

Future research using self-paced reading or eye-tracking-during-reading might help us clarify this issue further. If comprehenders find it unnatural to use certain verbs with number adverbials, then we might observe slowdown in reading time when encountering those expressions. Additionally, a follow-up experiment might also investigate comprehenders' processing behaviors for sentences with high or low repetition verbs without number adverbials. Eliminating the number adverbials can zero in on the verb semantics and may help validate the current findings.

Our results, which demonstrate that motion repetitions influence sensicality judgment and verb recall, are in line with other research. Language users' comprehension behaviors have been shown to be affected by verb semantics including the speed of a motion (*mope* vs. *sprint*) and the duration of a motion (traveling a long distance vs. traveling a short distance). Our findings show that the frequency of motion repetition also influences sentence comprehension and recall of information. Comprehenders' sensicality judgment was more accurate when the sentence was about actions that repeat once or twice in a row than when the sentence was about actions that repeat many times in a row. People also remembered verbs of low frequency actions more accurately than verbs of high frequency actions.

Processing sentences with low-repetition verbs might have been easier because they require simpler mental representations than sentences with high-repetition verbs. Building a mental representation of a motion that typically repeats multiple times may require more processing resources. This burden might have exhausted the processing capacity to accurately recognize the verbs later on.

Broadly speaking, our results extend prior work on sensitivity to verb semantics to lexical information regarding action repetition rates.

References

Bambini, V., Ghio, M., & Schumacher, P. B. (2012). Acceptability differences between metaphor, metonymy and approximation. *Quaderni del Laboratoria di Linguistica, 11*.

Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: MIT Press.

Fecica, A. & O'Neill, D. (2010). A step at a time: Preliterate children's simulation of narrative movement during story comprehension. *Cognition, 116*(3), 368-381.

Federmeier, K., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. *JML, 41*(4), 469-495.

Ferreira, V. S., & Yoshita, H. (2003). Given-new ordering effects on the production of scrambled sentences in Japanese. *JPR, 32*(6), 669-692.

Hofmeister, P., Jaeger, T. F., Arnon, I., Sag, I. A., & Snider, N. (2013). The source ambiguity problem: Distinguishing the effects of grammar and processing on acceptability judgments. *Language and Cognitive Processes, 28*(1-2), 48-87.

Innocenti, A., De Stefani, E., Sestito, M., & Gentilucci, M. (2014). Understanding of action-related and abstract verbs in comparison: a behavioral and TMS study. *Cognitive Processing, 15*(1), 85-92.

Klein, D. E., & Murphy, G. L. (2001). The representation of polysemous words. *JML, 45*(2), 259-282.

Lindsay, S., Scheepers, C., & Kamide, Y. (2013). To dash or to dawdle: Verb-associated speed of motion influences eye movements during spoken sentence comprehension. *PloS one, 8*(6), e67187.

Martin, A., & Chao, L. L. (2001). Semantic memory and the brain: structure and processes. *Current Opinion in Neurobiology, 11*(2), 194-201.

Matlock, T. (2004). Fictive motion as cognitive simulation. *Memory & Cognition, 32*, 1389–1400.

Mitchell, J., Lapata, M., Demberg, V., & Keller, F. (2010). Syntactic and semantic factors in processing difficulty: An integrated measure. *Proceedings of the 48th Annual Meeting of the Association for Computational Linguistics*, 196–206.

Moody, C. L., & Gennari, S. P. (2010). Effects of implied physical effort in sensory-motor and pre-frontal cortex during language comprehension. *Neuroimage, 49*(1), 782-793.

Murphy, G. L. (1991). Meanings and concepts. In P. Schwanenflugel (Ed.), The psychology of word meanings (pp. 11–35). Hillsdale, NJ: Erlbaum.

Pinker, S. (1994). *The language instinct*. New York: William Morrow.

Pulvermüller, F., Härle, M., & Hummel, F. (2001). Walking or talking?: Behavioral and neurophysiological correlates of action verb processing. *Brain and Language, 78*(2), 143-168.

Rappaport, M., Levin, B., & Laughren, M. (1993). *Levels of lexical representation* (pp. 37-54). Springer Netherlands.

Slevc, L. R. (2011). Saying what's on your mind: Working memory effects on sentence production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(6), 1503.

Stites, M. C., Luke, S. G., & Christianson, K. (2013). The psychologist said quickly, "Dialogue descriptions modulate reading speed!". *Memory & cognition, 41*(1), 137-151.

Ullman, M. T. (2001). A neurocognitive perspective on language: The declarative/procedural model. *Nature Reviews Neuroscience, 2*(10), 717-726.

Yao, B., & Scheepers, C. (2011). Contextual modulation of reading rate for direct versus indirect speech quotations. *Cognition, 121*(3), 447-453.