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Natural Forces as Agents: Reconceptualizing the Animate-Inanimate Distinction

Matthew W. Lowder and **Peter C. Gordon**
University of North Carolina at Chapel Hill

Abstract

Research spanning multiple domains of psychology has demonstrated preferential processing of animate as compared to inanimate entities—a pattern that is commonly explained as due to evolutionarily adaptive behavior. Forces of nature represent a class of entities that are semantically inanimate but which behave as if they are animate in that they possess the ability to initiate movement and cause actions. We report an eye-tracking experiment demonstrating that natural forces are processed like animate entities during online sentence processing: they are easier to integrate with action verbs than instruments, and this effect is mediated by sentence structure. The results suggest that many cognitive and linguistic phenomena that have previously been attributed to animacy may be more appropriately attributed to perceived agency. To the extent that this is so, the cognitive potency of animate entities may not be due to vigilant monitoring of the environment for unpredictable events as argued by evolutionary psychologists but instead may be more adequately explained as reflecting a cognitive and linguistic focus on causal explanations that is adaptive because it increases the predictability of events.

Keywords

animacy; agency; natural forces; sentence complexity; relative clauses; eye movements

The fundamental distinction between animate and inanimate entities is regarded as an important factor in language and cognitive processing. In language research, animacy is considered a linguistic universal (Comrie, 1989)—one that powerfully affects the acquisition of grammatical knowledge (Brown, 1973), the process of sentence comprehension (Clifton, Traxler, Mohamed, Williams, Morris, & Rayner, 2003), and the degree of language impairment in patients with aphasia and other neuropsychological conditions (Capitani, Laiacona, Mahon, & Caramazza, 2003). For cognition more generally, animate stimuli

Address correspondence to: Matthew W. Lowder, Institute for Mind and Brain, University of South Carolina, Columbia, SC 29201, lowdermw@mailbox.sc.edu.
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capture visual attention more quickly and hold attention longer than inanimate stimuli (Abrams & Christ, 2003; Johansson, 1973; Pratt, Radulescu, Guo, & Abrams, 2010). The distinction between animate and inanimate is a critical component of semantic knowledge (Caramazza & Mahon, 2003), emerges early in development (Opfer & Gelman, 2011), and is associated with distinct patterns of brain activation (Caramazza & Shelton, 1998; Gobbini et al., 2011). Finally, words or pictures representing animate entities are better remembered than those representing inanimate entities (Bonin, Gelin, & Bugaiska, 2013; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013; VanArsdall, Nairne, Pandeirada, & Cogdill, 2014).

Findings showing the importance of animacy are frequently explained from an evolutionary psychology perspective (e.g., *animate monitoring hypothesis;* New, Cosmides, & Tooby, 2007). Given that our primitive ancestors were primarily concerned with survival, the ability to rapidly detect animals in the visual field and determine whether they were potential predators or prey would seem to be a highly advantageous skill. In addition, survival and reproduction likely depended on the ability to remember which humans were friends, enemies, or potential mates. More generally, New et al. argue that the behavior of humans and animals is largely unpredictable, which would have made it especially advantageous for our ancestors to carefully monitor the location of animate entities more so than inanimate entities (like tools) that typically remained stationary. In other words, animate entities are capable of independent movement, can suddenly change course without warning, and occasionally initiate violent actions that result in destruction, injury, or death, all of which are argued to have contributed to an evolutionarily advantageous focus on animate entities.

While many cognitive and linguistic phenomena have been cited as showing the importance of animacy, animacy per se may not be the critical factor. *Natural forces* are semantically inanimate (nonliving), but behave in ways that are more similar to animates than inanimates in that they are able to initiate movement, change course without warning, and occasionally cause destruction, injury, and death. Accounts of evolutionary psychology cite extreme climate and natural disasters as important factors that likely shaped the prehistoric evolution of human behavior (Buss, 1991, 2009). Recorded history on supernatural beliefs found from classical mythology to modern religion provides ample evidence that humans are inclined to attribute volitional characteristics to inanimate forces of nature just as they do to animate entities (Guthrie, 1993). This suggests that cognitive focus may be guided by the perceived agency of an entity rather than its animacy, and further, that the cognitive potency of animate entities is not solely due to processes that vigilantly monitor the environment for unpredictable events but instead depends in very important ways on processes involved in creating causal explanations that are adaptive because they increase the predictability of events.

Analyses of language further indicate that this focus on the causal explanations of events is linguistically encoded in the basic processes that govern how subjects and verbs combine in sentences. Standard linguistic accounts (Chomsky, 1981) propose that a verb assigns thematic roles, which specify semantically how the arguments introduced by noun phrases combine with the actions introduced by the verb. For example, a verb like *injure* assigns the thematic role of “agent” to its subject, which requires that the subject be animate (1a). If instead the subject is inanimate (1b), it may still be possible to understand the sentence, but processing is made more difficult (Lowder & Gordon, 2012).

(1a) The criminal injured the farmer in the field beside the barn.

(1b) The revolver injured the farmer in the field beside the barn.

This difficulty with inanimate subject-verb integration may result from additional processing required in assigning a less-preferred *instrument* role to the subject (Cruse, 1973; Fillmore, 1968; Schlesinger, 1989). However, Dowty (1991) has argued that discrete thematic role categories, such as *agent* and *instrument*, should be replaced by the notion of a Proto-Agent. Under this account, the Proto-Agent possesses the properties that are typically associated with thematic agents (i.e., volition, sentience, ability to change the state of another entity, movement), and a verb may assign an argument the Proto-Agent role to the extent that it resembles the prototype. Thus, it is possible for animate entities, natural forces, and instruments to participate in an event as Proto-Agents, but their degree of fit with this category may vary. From this perspective, the animacy of an entity referred to by a noun is less important than its *perceived agency*—the degree to which it is conceptualized as possessing the ability to initiate actions. A similar perspective comes from Wolff and colleagues (Wolff, Jeon, Klettke, & Li, 2010; Wolff, Jeon, & Li, 2009), who have proposed that the difficulty of interpreting a causal construction involving an inanimate subject depends on the entity's inherent ability to generate its own energy. Under this account, inanimate entities lie on a *continuum of force creation*. On one end are natural forces (e.g., hurricanes, earthquakes, rivers), which are fully capable of creating their own energy. On the other end are instruments, tools, and weapons, which derive their energy from an animate agent, and therefore may not easily combine with an action verb.

Consistent with the notion that animacy influences the process of subject-verb integration, we have shown using eye-tracking that readers experience greater processing difficulty in sentences like (1b) than in sentences like (1a), where the action verb is the main verb of the sentence. However, when the action verb is embedded in a relative clause (1c & 1d), the animacy effect is substantially reduced (Lowder & Gordon, 2012).

(1c) The criminal that injured the farmer was beside the barn.

(1d) The revolver that injured the farmer was beside the barn.

This pattern of effects is important for several reasons. First, it demonstrates that semantic-thematic mismatches impose a processing cost. Second, it illustrates that this cost is mediated by sentence structure, which we argue directs the reader's attention away from the relationships established in the relative clause and focuses the reader instead on the information asserted in the main clause (see also Lowder & Gordon, 2013, in press). Finally, and most critical to the current investigation, this pattern of effects suggests that this paradigm is particularly well-suited for examining the processing of different types of inanimate nouns.

The current experiment tests the hypothesis that natural forces are processed like animate nouns during subject-verb integration. Specifically, this hypothesis predicts that integration of an inanimate subject with an action verb is easier when the subject represents a natural force (e.g., tornado) than when it represents an instrument (e.g., revolver). In addition, if nouns referring to natural forces interact with sentence structure in the same way as do nouns referring to animate entities, then the difference between instruments and natural forces should be reduced by clausal separation as it is for inanimate and animate entities (Lowder & Gordon, 2012). This account predicts that instruments should cause greater processing difficulty than natural forces in a simple sentence context, but that this effect should be reduced when the action verb is deemphasized by embedding it in a relative clause. Obtaining this pattern of results would suggest that many cognitive and linguistic phenomena that have previously been attributed to animacy should instead be seen as resulting from perceived agency.

Method

Participants

Fifty-two native-English-speaking students at the University of North Carolina at Chapel Hill participated in exchange for course credit.

Materials

There were 32 experimental sentences, as in (2), and 88 filler sentences. The subject of each experimental sentence represented either a natural force or an instrument. The subject combined with the action verb in either a simple-sentence context or inside a relative clause.

(2a) *The tornado injured the farmer in the field beside the barn.* (Natural-Simple)

(2b) *The revolver injured the farmer in the field beside the barn.* (Instrument-Simple)

(2c) *The tornado that injured the farmer was beside the barn.* (Natural-Relative Clause)

(2d) *The revolver that injured the farmer was beside the barn.* (Instrument-Relative Clause)

The natural forces included weather-related events (*hurricane, blizzard, rain*), geological phenomena (*earthquake, mudslide, volcano*), and water-related forces (*river, stream, undertow*). The instruments consisted primarily of tools (*hammer, wrench, crowbar*) and weapons (*pistol, sword, machete*). The natural forces and instruments did not differ in length, log frequency (SUBTLEX$_{US}$, Brysbaert & New, 2009), or imageability (for the 20 natural forces and 19 instruments that appeared in the N-Watch database, Davis, 2005)[1]. The verbs expressed an action and always took as arguments an agent and a patient (*carried*,

[1]It seems natural to wonder whether there were differences between the Natural-Force and Instrument conditions in frequency of occurrence for the subject-verb pairs or the subject-verb-patient combinations. This question is difficult to address given that sequences of specific words often do not appear at all even in very large corpora. Only 26 of our 64 subject-verb pairs (e.g., *tornado injured; revolver injured*) appeared even once in the Google N-Gram corpus (Brants & Franz, 2006), which consists of approximately one trillion words—a far larger language sample than any individual could possibly encounter in a lifetime of language experience. An alternative approach to frequency that avoids the sparse nature of corpus counts for specific word sequences is to use a method like Latent Semantic Analysis (LSA; Landauer & Dumais, 1997), which provides estimates of semantic similarity of words based on patterns of co-occurrence across multiple texts. For our materials, LSA similarity scores did not differ significantly between Natural-Force and Instrument conditions for the subject-verb sequences (e.g., *tornado/revolver injured*) or the subject-verb-patient sequences (*tornado/revolver injured the farmer*). Even if LSA had shown differences it would not have provided information about whether those differences were due to semantic distinctions such as agency or animacy.

wounded, *damaged*). The Relative-Clause condition was created by inserting the complementizer *that* between the subject and target verb, and then rewriting the remainder of the sentence.

Procedure

Eye-movements were recorded with an EyeLink 1000 system (SR Research). At the start of each trial, a fixation point was presented near the left edge of the monitor. Once gaze was steady, the experimenter presented the sentence. After reading the sentence, the participant pressed a key, which replaced the sentence with a true-false comprehension question (e.g., True or False: The tornado/revolver was beside the barn). Participants responded using a handheld console. Mean accuracy was 91%.

Each participant first read four of the filler sentences. After this warm-up block, the remaining 116 sentences were presented randomly.

Analysis

Data analysis focused on three standard measures. *Gaze duration* is the sum of all initial fixations on a region, beginning when the region is first fixated and ending when gaze is directed away from the region. *Regression-path duration* is the sum of all fixations beginning with the initial fixation on a region and ending when the gaze is directed away from the region to the right. *Rereading duration* is the sum of all fixations on a region that are not included in gaze duration. Unlike the other measures, rereading duration includes zeroes.

Reading times are reported for two regions of interest. The *verb region* (e.g., *injured*) was the main verb in the Simple-Sentence condition and the embedded verb in the Relative-Clause condition. For this region, we implemented a contingent-expansion for the Relative-Clause condition (Lowder & Gordon, 2012; Rayner & Duffy, 1986), such that on trials where the verb was skipped during first-pass reading but the complementizer was fixated, reading time on the complementizer was used in place of the verb. The *spillover region* (e.g., *the farmer*) consisted of the determiner and noun immediately following the verb.

An automatic procedure combined fixations that were shorter than 80 ms and within one character of another fixation into a single fixation and removed any additional fixations that were shorter than 80 ms, affecting 3% of the data. For all dependent measures, any extremely large values (exceeding 5,000 ms) were excluded (one data point). Subsequently, means and standard deviations were computed separately for each condition, region of interest, and dependent measure. Times greater than 2.5 SDs from the condition mean were eliminated, affecting 2.6% of the data.

Results

Verb region

Reading times are presented in Table 1. Analysis of all measures on the verb revealed main effects of sentence structure such that times were longer in the Simple-Sentence condition than the Relative-Clause condition. The effect was significant in gaze duration, $F_1(1,51)$ =

23.96, $p < .001$; $F_2(1,31) = 50.99$, $p < .001$, regression-path duration, $F_1(1,51) = 12.29$, $p < .005$; $F_2(1,31) = 12.79$, $p < .005$, and rereading duration, $F_1(1,51) = 27.90$, $p < .001$; $F_2(1,31) = 15.73$, $p < .001$. In addition, there were main effects of subject type in regression-path duration, $F_1(1,51) = 29.22$, $p < .001$; $F_2(1,31) = 12.59$, $p < .005$, and rereading duration, $F_1(1,51) = 9.79$, $p < .005$; $F_2(1,31) = 3.91$, $p = .057$, such that reading times were longer in the Instrument condition than the Natural-Forces condition.

Crucially, these main effects were qualified by interactions between sentence structure and subject type. The interaction was significant in regression-path duration (marginal in the item analysis), $F_1(1,51) = 4.09$, $p < .05$; $F_2(1,31) = 3.40$, $p = .075$, such that the effect of subject type in the Simple-Sentence condition (64 ms), $t_1(51) = 4.90$, $p < .001$; $t_2(31) = 2.12$, $p < .05$, was over twice as large as in the Relative-Clause condition (28 ms). This effect is illustrated in the left panel of Figure 1. The interaction was fully significant in rereading duration, $F_1(1,51) = 10.75$, $p < .005$; $F_2(1,31) = 4.83$, $p < .05$, such that there was a significant effect of subject type in the Simple-Sentence condition, $t_1(51) = 4.00$, $p < .001$; $t_2(31) = 2.66$, $p < .02$, but no difference in the Relative-Clause condition, ts < 1.

Spillover region

Analysis of gaze duration revealed no effects. In contrast, analysis of regression-path duration revealed a significant main effect of sentence structure, $F_1(1,51) = 33.50$, $p < .001$; $F_2(1,31) = 13.10$, $p < .005$, such that reading times were longer for the Simple-Sentence condition than the Relative-Clause condition, and a significant main effect of subject type (marginal in the item analysis), $F_1(1,51) = 7.74$, $p < .01$; $F_2(1,31) = 2.86$, $p = .10$, such that reading times were longer in the Instrument condition than the Natural-Forces condition.

Critically, these main effects were qualified by interactions between sentence structure and subject type. The interaction was significant in regression-path duration, $F_1(1,51) = 5.62$, $p < .03$; $F_2(1,31) = 4.49$, $p < .05$, such that there was a significant effect of subject type in the Simple-Sentence condition, $t_1(51) = 3.62$, $p < .005$; $t_2(31) = 2.40$, $p < .03$, but no difference in the Relative-Clause condition, ts < 1. This effect is illustrated in the right panel of Figure 1. The interaction was also significant in rereading duration, $F_1(1,51) = 6.34$, $p < .02$; $F_2(1,31) = 4.72$, $p < .05$, such that there was an effect of subject type in the Simple-Sentence condition, $t_1(51) = 2.43$, $p < .02$; $t_2(31) = 1.98$, $p = .057$, but not in the Relative-Clause condition, ts < 1.20, ps > .23.

Discussion

Although instruments and natural forces are both classes of inanimate entities, the current experiment demonstrated distinct processing patterns for these nouns during subject-verb integration. Integration of an instrument with an action verb caused early and sustained processing difficulty compared to integration of a natural force with an action verb. Importantly, this effect was robust when the action verb was the main verb but was almost completely eliminated when the verb was embedded in a relative clause. This pattern is consistent with our previous work showing that the processing of a semantic mismatch compared to a more straightforward interpretation depends on sentence structure (Lowder & Gordon, 2012, 2013, in press). In light of our previous work, these results suggest that the integration of an instrument with an action verb represents a semantic mismatch that imposes a processing cost on the reader, whereas the integration of a natural force with an action verb involves a more straightforward interpretation, as has been found previously with animate entities.

These findings are consistent with linguistic accounts that have noted that inanimate entities vary with respect to their acceptability as causers of events. According to these accounts, an action verb, which semantically requires an animate subject, can also take certain inanimate subjects if they possess characteristics typically associated with agents (Dowty, 1991) or if they are able to generate their own energy (Wolff et al., 2009, 2010). Accordingly, subject-verb integration is straightforward when the subject refers to an entity that is easily perceived as an agent (be it a human, animal, or force of nature) but is more difficult when the subject refers to an entity that is not easily perceived as an agent (be it an instrument, tool, or weapon); in these latter cases, additional processing is needed to resolve the mismatch between the thematic requirements of the verb and the semantic features of the subject. These results build on evidence that language implicitly codes information that is relevant to basic principles about how the world works (Brown & Fish, 1983). Language tends to focus the entities around us—whether animate or inanimate—that are perceived as agents or as causal in other ways. By doing so, linguistic encoding reinforces the importance of agency and causality, and provides an effective medium in which to accumulate and transmit cultural knowledge about how the world works.

Although a great deal of research has been presented as showing a processing advantage in attention, memory, and other cognitive domains for animate compared to inanimate entities (e.g., Abrams & Christ, 2003; Bonin et al., 2013; Capitani et al., 2003; Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Gobbini et al., 2011; Johansson, 1973; Nairne et al., 2013; New et al., 2007; Pratt et al., 2010; VanArsdall et al., 2014), the current results suggest that these effects may instead be due to the ease with which an entity is perceived as an agent. Demonstrations of an advantage for processing animate versus inanimate entities have been cited as evidence for the evolutionary pruning of the human mind to adapt to the primeval challenges of survival (Nairne et al, 2013; New et al., 2007). These accounts argue that onset of movement and unpredictable changes in behavior are key factors that contributed to the evolutionarily adaptive ability to selectively attend to animate over inanimate entities. Importantly, however, forces of nature are often characterized in the same way as animate beings. In cultures throughout history, the wind has been interpreted as the breathing of the gods, thunder as a voice, rain as tears, storms as anger (Guthrie, 1993). Even members of highly industrialized societies refer to forces of nature as if they are animate. We describe winds as “harsh” or “gentle,” volcanoes as “active” or “dormant,” seas as “raging” or “calm.” We make references to Mother Earth, we name hurricanes, and we claim to see a man in the moon. Such widespread anthropomorphism could reflect a genetically-encoded, adaptive focus on agency that evolved because it promoted the survival of primitive humans. Alternatively, it could reflect a linguistically-encoded, adaptive focus on the causes of events, which is intimately related to the human desire to predict actions and events in order to facilitate interactions with the world.

References

Abrams RA, Christ SE. Motion onset captures attention. Psychological Science. 2003; 14:427–432. [PubMed: 12930472]

Bonin P, Gelin M, Bugaiska A. Animates are better remembered than inanimates: Further evidence from word and picture stimuli. Memory & Cognition. 2014; 42:370–382. [PubMed: 24078605]

Brants, T.; Franz, A. Web 1T 5-gram version 1. Philadelphia: Linguistic Data Consortium; 2006.

Brown, R. A first language: The early stages. Cambridge, MA: Harvard; 1973.

Brown R, Fish D. The psychological causality implicit in language. Cognition. 1983; 14:237–273. [PubMed: 6686101]

Brysbaert M, New B. Moving beyond Kucera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. Behavior Research Methods. 2009; 41:977–990. [PubMed: 19897807]

Buss DM. Evolutionary personality psychology. Annual Review of Psychology. 1991; 42:459–461.

Buss DM. The great struggles of life: Darwin and the emergence of evolutionary psychology. American Psychologist. 2009; 64:140–148. [PubMed: 19203146]

Capitani E, Laiacona M, Mahon B, Caramazza A. What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. Cognitive Neuropsychology. 2003; 20:213–261. [PubMed: 20957571]

Caramazza A, Mahon BZ. The organization of conceptual knowledge: The evidence from category-specific semantic deficits. Trends in Cognitive Sciences. 2003; 7:354–361. [PubMed: 12907231]

Caramazza A, Shelton JR. Domain-specific knowledge systems in the brain: The animate-inanimate distinction. Journal of Cognitive Neuroscience. 1998; 10:1–34. [PubMed: 9526080]

Chomsky, N. Lectures on government and binding. Dordrecht: Foris; 1981.

Clifton C Jr, Traxler MJ, Mohamed MT, Williams RS, Morris RK, Rayner K. The use of thematic role information in parsing: Syntactic processing autonomy revisited. Journal of Memory and Language. 2003; 49:317–334.

Comrie, B. Language universals and linguistic typology. Chicago: University of Chicago Press; 1989.

Cruse DA. Some thoughts on agentivity. Journal of Linguistics. 1973; 9:11–23.

Davis CJ. N-Watch: A program for deriving neighborhood size and other psycholinguistic statistics. Behavior Research Methods. 2005; 37:65–70. [PubMed: 16097345]

Dowty DR. Thematic proto-roles and argument selection. Language. 1991; 67:547–619.

Fillmore, CJ. The case for case. In: Bach, E.; Harris, RT., editors. Universals in linguistic theory. New York: Holt, Rinehart, & Winston; 1968.

Gobbini MI, Gentili C, Ricciardi E, Bellucci C, Salvini P, Laschi C, Pietrini P. Distinct neural systems involved in agency and animacy detection. Journal of Cognitive Neuroscience. 2011; 23:1911–1920. [PubMed: 20849234]

Guthrie, S. Faces in the clouds: A new theory of religion. New York: Oxford University Press; 1993.

Johansson G. Visual perception for biological motion and a model for its analysis. Perception & Psychophysics. 1973; 14:201–211.

Landauer TK, Dumais ST. A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge. Psychological Review. 1997; 104:211–240.

Lowder MW, Gordon PC. The pistol that injured the cowboy: Difficulty with inanimate subject-verb integration is reduced by structural separation. Journal of Memory and Language. 2012; 66:819–832.

Lowder MW, Gordon PC. It's hard to offend the college: Effects of sentence structure on figurative-language processing. Journal of Experimental Psychology: Learning, Memory, & Cognition. 2013; 39:993–1011.

Lowder MW, Gordon PC. The manuscript that we finished: Structural separation reduces the cost of complement coercion. Journal of Experimental Psychology: Learning, Memory, & Cognition. in press. 10.1037/xlm0000042

Nairne JS, VanArsdall JE, Pandeirada JNS, Cogdill M, LeBreton JM. Adaptive memory: The mnemonic value of animacy. Psychological Science. 2013; 24:2099–2105. [PubMed: 23921770]

New J, Cosmides L, Tooby J. Category-specific attention for animals reflects ancestral priorities, not expertise. Proceedings of the National Academy of Sciences. 2007; 104:16598–16603.

Opfer, JE.; Gelman, SA. Development of the animate-inanimate distinction. In: Goswami, U., editor. The Wiley-Blackwell handbook of childhood cognitive development. 2. Oxford: Wiley-Blackwell; 2011. p. 213-238.

Pratt J, Radulescu PV, Guo RM, Abrams RA. It's alive! Animate motion captures visual attention. Psychological Science. 2010; 21:1724–1730. [PubMed: 20974713]

Rayner K, Duffy SA. Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. Memory & Cognition. 1986; 14:191–201. [PubMed: 3736392]

Schlesinger IM. Instruments as agents: On the nature of semantic relations. Journal of Linguistics. 1989; 25:189–210.

VanArsdall JE, Nairne JS, Pandeirada JNS, Cogdill M. Adaptive memory: Animacy effects persist in paired-associate learning. Memory. 2014

Wolff, P.; Jeon, G.; Klettke, B.; Li, Y. Force creation and possible causes across languages. In: Malt, B.; Wolff, P., editors. Words and the mind: How words capture human experience. Oxford: Oxford University Press; 2010.

Wolff P, Jeon G, Li Y. Causers in English, Korean, and Chinese and the individuation of events. Language and Cognition. 2009; 1:167–196.

Highlights

- Natural forces are easier to integrate with action verbs than instruments.
- This effect is modulated by sentence structure.
- This pattern is similar to work that compared animate and inanimate nouns.
- Perceived agency seems to be a more important factor than animacy.

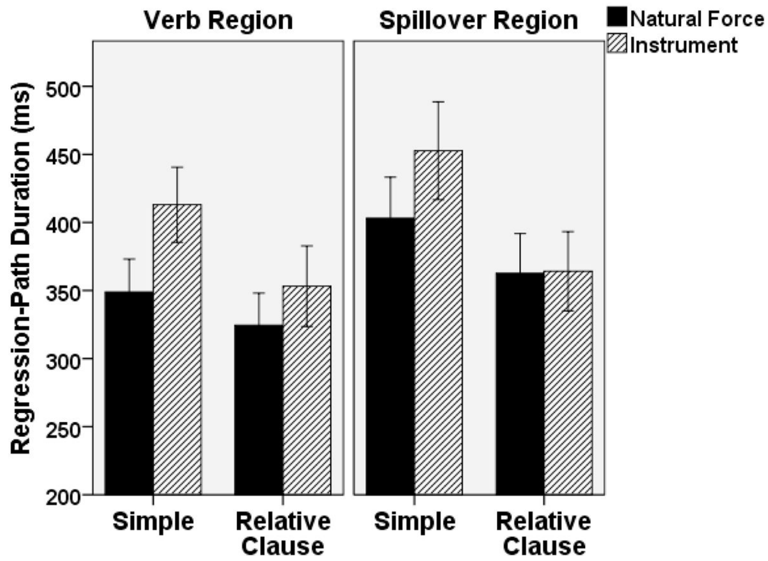

Figure 1.
Mean regression-path durations on the verb and spillover regions, presented as a function of subject type and sentence structure. Error bars represent 95% confidence intervals.

Table 1

Eye-tracking results.

Region of Interest	Condition	Measure (in milliseconds)		
		Gaze Duration	Regression-Path Duration	Rereading Duration
Verb	Natural-Simple	296	349	191
	Instrument-Simple	312	413	259
	Natural-Relative Clause	267	325	162
	Instrument-Relative Clause	268	353	159
Spillover	Natural-Simple	303	403	163
	Instrument-Simple	300	453	203
	Natural-Relative Clause	307	363	179
	Instrument-Relative Clause	314	364	159