Effects of Text Exposure on Spoken Sentence Production

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Abstract

Adults are sophisticated language users, and there is much debate as to the maturational and experiential changes that occur throughout childhood to bring about these abilities. We propose that the onset of literacy may be an important event in the course of language development, as it marks a qualitative shift in the linguistic patterns to which an individual is exposed. In Experiment 1, we investigate the frequencies of two complex sentence types in child-directed speech and literature. In Experiment 2, these sentence types are elicited from eight and twelve year old children and adults in a picture-description production task. Differences between written and spoken language predict both group differences and individual differences in text exposure on the production task. Linguistic experience gained from reading may affect spoken production choices, and the onset of literacy may be an important predictor for what in the laboratory is deemed adult-like language use.

Keywords: Sentence production; relative clauses; corpus analysis; literacy.

Introduction

By adulthood, language users can rapidly access their knowledge of different patterns, at different grain sizes, when producing and comprehending language. This sophisticated language ability takes time to develop, and there is much debate as to the sorts of changes that occur across the developmental trajectory that eventually yield these language abilities. This is especially true of complex sentences, particularly those containing relative clauses, as these sentence types tend to have longer developmental trajectories and even in adults are thought to tax working memory or other language abilities (Gibson, 1998; Just & Carpenter, 1992; Miller & Chomsky, 1963). Indeed, many theories of language development suggest that children struggle with complex sentences because they tax working memory capacity (deVilliers et al., 1979) or reflect children's limited syntactic competence (Goodluck & Tavakolian, 1982)

More recent theories suggest that children's limited linguistic experience may contribute to their difficulty with these complex sentences. Children's use of relative clauses (Diessel & Tomasello, 2005) and other language constructions tend to track their linguistic input (Bates & MacWhinney, 1987; Cameron-Faulkner, Lieven & Tomasello, 2003; Huttenlocher et al., 2002; Naigles & Hoff-Ginsberg, 1998). Quantifying the types of experience that a child may have with a particular sentence type may be crucial for understanding children's comprehension and production behavior.

In order to quantify a child's experience with a particular sentence type, it is important to consider experience from both the spoken, and when a child learns how to read, the written domain. This is particularly true of sentences containing object relative (1) and passive relative clauses (2a,b), which are known to have different distributions in written and spoken language in adult-directed sources (Reali & Christiansen, 2007; Roland, Dick & Elman, 2007). These systematically different linguistic patterns in written and spoken language suggests that learning to read might mark an important period of change in language development, in which there is a qualitative shift in the pattern of language statistics and individual encounters. The goal of the present study is to determine whether these sentence types also occur with different patterns in child-directed written and spoken language, and use differences in the patterns between these domains to make predictions about eight and twelve-year old children and adults' production patterns in a picture-description production task.

1) Object Relative: The ball that the man is throwing
2a) Be-Passive Relative: The ball that is being thrown by the man
2b) Get-Passive Relative: The ball that is getting thrown by the man

These sentence types are a particularly interesting arena to investigate effects of reading because previous research suggests that in adult-directed sources, object relative clauses (1) tend to be more frequent in spoken language while passive relatives (2a,b) tend to be more frequent in written language (Roland et al., 2007). If these patterns appear in child-directed sources as well, we would predict that older children, or children who are better readers, might produce more passive relatives than younger children or poorer readers. Previous work also suggests that in main clause utterances, get-passives (2b) are more frequent in spoken language than be-passives (2a), while opposite is true of written language (Biber et al., 1999; Collins, 1996). Again, we would predict that older children or better readers should produce more be-passives, consistent with their higher rates of exposure to patterns of written language.

Experiment 1 consists of corpus analyses of child-directed speech (CHILDES; MacWhinney, 2000) and children's

literature (COCA; Davies, 2008-). The goal is to determine the frequencies of object and passive relative clauses in child-directed written and spoken language, in order to gauge children's experience with these constructions, and use the these environmental patterns to make predictions about production patterns. Experiment 2 is a production study that elicits object and passive relative clauses from eight and twelve year old children and adults. We used a task that has previously been used to elicit object and passive relative clauses in adults (Gennari, Mirkovic & MacDonald, 2012; Montag & MacDonald, 2014).

Previous work suggests that language experience via reading has a significant effect on language comprehension abilities, but an effect of text exposure on production choices would be a novel finding. This is important not only to better understand the motivations behind production choices, but would also provide strong support for an experience-based theory of language development. Further, if differences in the production patterns of children and adults or between individuals with more or less text exposure vary along the dimensions that distinguish written and spoken language, we would implicate reading as an important source of language statistics for an individual's attainment of what in the lab is deemed adult-like language behavior.

Experiment 1: Corpus Analyses

Two corpus analyses aim to quantify the patterns of object and passive relative clause use in child-directed written and spoken language.

Written Corpus

The written corpus used was the juvenile literature[1] contained in the COCA (Corpus of Contemporary American English) corpus (Davies, 2008-). This corpus consists of 2.40 million words of literature intended for children aged 3-16 years. It consists of fiction and non-fiction magazine articles and excerpts from fiction novels from 97 different sources (magazine and book titles). Part of speech tags were used to extract possible relative clauses. We then eliminated irrelevant sentences by hand.

Spoken Corpus

The spoken corpus used was a 1.12 million word[2] subset of the parsed CHILDES (MacWhinney, 2000) corpus of adults speaking to children between the ages of six months and five years. The CLAN program was used to extract all complement modifications, which contains all relative clauses. All sentences containing object and passive relative caluses were then extracted from these sentences by hand.

[1] In the version of COCA used in these analyses (updated June 6, 2012) about a quarter of the documents categorized as juvenile literature were not juvenile literature. All reported data removes these irrelevant documents.

[2] The CHILDES corpora used were Bates, Bernstein, Bliss, Bloom (1970), Bloom (1973), Bohannon, Brent and Brown.

Corpus Coding

All relative clauses were coded not only for whether they were an object relative or be/get passive relative, but for a number of additional factors shown to affect production patterns and/or comprehension difficulty: Animacy of the head noun (e.g. *the book/teacher that the student saw*), whether or not the relative clause was preceded by a relative pronoun (e.g. *The book that I read* vs. *The book I read*). Object relatives were further coded for the animacy of the embedded noun and type of embedded noun (pronoun or full noun phrase, e.g. (*The book the teacher read* vs. *The book she read*). Passive relatives were coded for whether an agent was specified (e.g. *The book that was read* vs. *The book that was read by the teacher*). This coding allowed us to make predictions about the production choices that speakers might make in Experiment 2 if they were affected by patterns of spoken and written language. If production choices are affected by both sets of patterns, then older individuals and individuals with more text exposure should make choices more similar to the patterns in written language, reflecting their greater amount of experience.

Results

As shown in Tables 1, 2, and 3, there are substantial differences between the patterns of object and passive relative clause use in the written and spoken corpora. There is no table for passive relatives found in the spoken corpus because only 3 passive relative utterances were found. Most relevant for the predictions of Experiment 2, the overall rates of object and passive relative use varied between the two corpora. Per million noun phrases, we found 8,925 object and 3,359 passive relatives in the written corpus and 1,879 object and 15 passive relatives per million noun phrases in the spoken corpus (raw counts: Written: 3,300 object and 1,242 passive relative; Spoken: 383 object and 3 passive relative). All passive relative tokens were be-passive, because get-passives tend to be a feature of spoken language and are uncommon in written language, and passives were overall extremely rare in the spoken corpus.

The first important finding is that there are overall more relative clauses, of either type, in the written corpus. The second important finding is that the ratios of object to passive relatives vary between the two corpora. In the written corpus, there are 2.7 object relatives for each passive relative while in the spoken corpus, there are 125 object relatives for each passive relative. These frequencies are consistent with the results of previous corpus analyses of object and passive relative clause distributions (Roland, et al., 2007). Even in child-directed written and spoken corpora, text not only provides more complex utterances of any type, but disproportionately more experience with passive relative clauses.

This is the first corpus analysis specifically investigating relative clause use in child-directed speech and literature, and it will be an important tool for predicting relative clause production and comprehension patterns in this, and future work with children.

Table 1: Summary of object relative clauses in COCA juvenile literature per million NPs.

	With Relative Pronoun		Total	No Relative Pronoun		Total	Grand Total
	Animate Head Noun	Inanimate Head Noun		Animate Head Noun	Inanimate Head Noun		
Embedded Full NP	11	203	214	35	417	452	665
Animate	11	162	173	30	354	384	557
Inanimate	0	41	41	5	62	68	108
Embedded Pronoun	92	847	938	1209	6112	7321	8260
Animate	87	841	928	1204	6050	7254	8181
Inanimate	5	5	11	5	62	68	78
Grand Total	103	1049	1152	1244	6529	7773	8925

Table 2: Summary of passive relative clauses in COCA juvenile literature per million NPs.

	With Relative Pronoun		Total	No Relative Pronoun		Total	Grand Total
	Animate Head Noun	Inanimate Head Noun		Animate Head Noun	Inanimate Head Noun		
Agent	8	38	46	46	400	446	492
No Agent	89	257	346	435	2085	2521	2867
Grand Total	97	295	392	481	2486	2967	3359

Table 3: Summary of object relative clauses in CHILDES child-directed speech per million NPs.

	With Relative Pronoun		Total	No Relative Pronoun		Total	Grand Total
	Animate Head Noun	Inanimate Head Noun		Animate Head Noun	Inanimate Head Noun		
Embedded Full NP	0	15	15	0	29	29	44
Animate	0	10	10	0	20	20	29
Inanimate	0	5	5	0	10	10	15
Embedded Pronoun	15	358	373	103	1359	1462	1835
Animate	15	353	368	103	1349	1452	1820
Inanimate	0	5	5	0	10	10	15
Grand Total	15	373	388	103	1389	1492	1879

Experiment 2: Sentence Production

This production study elicits object and passive relative clauses in children and adults with a production task similar to that of Gennari, et al. (2012) and Montag and MacDonald (2014). Participants also completed measures of text exposure. Given the large differences in relative clause usage found in the corpus analyses of Experiment 1, individuals with more text exposure (older children and those who spend more time reading) should produce more passive relative clauses than those with less text exposure.

Method

Participants Thirty undergraduates at the University of Wisconsin-Madison participated in exchange for course credit in an introductory psychology course. All were native speakers of American English. Thirty eight-year old children (15 female; mean age 8,3; SD 7.4 months; range 6,11-9,1) and 30 twelve year old children (9 female; mean age 12,2; SD 4.8 months; range 11;3-12;11) in the Madison, Wisconsin area also participated in exchange for a $10 gift card. All were native speakers of American English.

Materials Eighteen verbs that can each take both an animate or inanimate grammatical object were selected, and color illustrations were created that depicted two instances of that verb, once with a human agent acting on an animate entity and once acting on an inanimate entity. For example, the picture for the verb 'throw' (Figure 1) incorporated both a man being thrown and a ball being thrown. This animacy manipulation was an independent variable of the study.

Additional materials were used to estimate text exposure in children and adults. For adults we used the author recognition task and reading habits questionnaire used by Acheson, Wells and MacDonald (2008). For children, we created a title recognition task appropriate for eight and twelve year old children. This task was a modified and updated version of the children's title recognition task of Cunningham and Stanovich (1990).

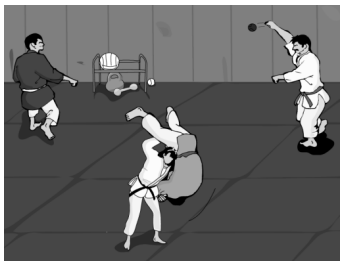

Figure 1: Test picture for verb "throw."

Procedure Written instructions appeared on a computer monitor and participants were instructed to read the instructions to themselves. All participants were presented with the same instructions, but the experimenter read the instructions aloud to the 8-year olds while the text was on the monitor. This was the only difference in experimental

procedure across age groups. These instructions described a cover task, in which participants were told that this task was about describing pictures, and another group of participants may try to guess which pictures they are describing. They were told that because various aspects of the pictures may be changed, describing the actions in which the people and objects were taking part would be the best strategy to employ in order to complete the task. Participants were never given sample object or passive relative clauses in the instructions or at any other point during the task.

In each trial, a color picture appeared on the screen and after three seconds, participants heard a question asking about the target person or object in the picture (for example, *Who is wearing orange?* or *What is red?* referring to the man or the ball in Figure 1) and answered the question by speaking into a microphone. Each participant saw nine animate and nine inanimate trials, and items were counterbalanced so that each participant saw each picture only once. Test and filler trials were pseudo-randomized such that there was always at least one filler trial between test trials. After the production task, participants performed either the author (adults) or title recognition task (children).

Results

Responses tended to contain object and passive relative clauses. Sentences 1, 2a and 2b list sample responses for the inanimate target "ball." Responses that did not contain a relative clause with a verb were excluded. Exclusion rates were low, at only 29.4% for eight year olds, 15.4% for twelve year olds and 15.6% for adults. The remaining responses were coded as containing either an object, be-passive or get-passive relative clause. Response data are shown in Figure 2.

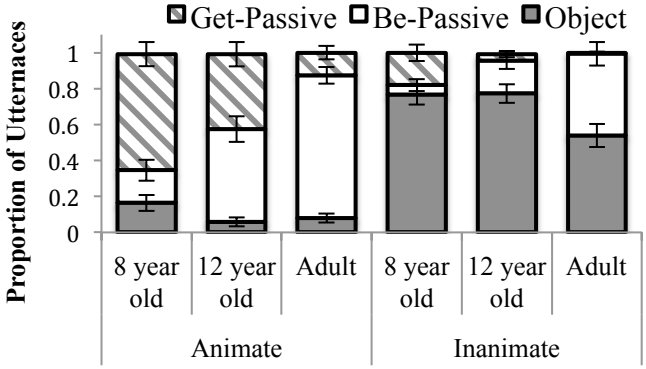

Figure 2: Proportion of object, be-passive and get-passive productions by age and animacy.

When target entities were animate, adults produced 8.0% (SD=14.1) object relative responses, 79.3% (SD = 25.7) be-passive and 12.7% (SD = 21.2) get-passive responses; twelve year olds produced 5.9% (SD = 13.7) object relative responses, 51.7% (SD = 39.5) be-passive and 41.5% (SD = 37.8) get-passive responses and eight year-olds produced 16.5% (SD = 24.6) object relative responses, 18.1% (SD = 31.9) be-passive and 64.6% (SD = 36.6) get-passive utterances. Three passive utterances (twelve year-olds: two; eight year-olds; one) contained neither get nor be (e.g. *the ball thrown by the man*), accounted for less than 1% of total utterances. When target entities were inanimate, adults produced 54.0% (SD = 35.4) object relative responses, 45.4% (SD = 35.7) be-passive and 0.7% (SD = 3.7) get-passive responses; twelve year olds produced 77.3% (SD = 28.6) object relative responses, 18.3% (SD = 26.4) be-passive and 3.6% (SD = 9.5) get-passive responses and eight year-olds produced 76.5% (SD = 29.7) object relative responses, 5.5% (SD = 18.5) be-passive and 18.0% (SD = 25.4) get-passive utterances. In addition, twelve year olds produced two passive utterances with neither get nor be, accounting for less than 1% of total responses.

Production choices significantly varied by animacy and age. Using mixed-effects logistic regression (glmer) in the lme4 package in R (Bates et al., 2013), when comparing the use of an object relative to any passive form, all age groups showed an effect of animacy ($z = 7.03$, $p < 0.001$) such that speakers produced more passive utterances when describing animate entities. Further, there was a linear trend, such that older speakers produced more passive utterances than younger speakers ($z = 4.40$, $p < 0.001$). Within passive utterances the rate of be-passive use also increased with age ($z = 7.55$, $p < 0.001$). These age-related results are consistent with the corpus analyses of Experiment 1. Older children and adults, who presumably have more text exposure, tend to produce more utterance forms characteristic of written language, yielding more passive relative utterances and more be-passive utterances with age.

Though group differences show a greater rate of passive relative use with age and text exposure, the overall rate of passive use, especially with animate targets is quite high, even for the youngest participants. This result reflects finer-grained patterns in speakers' experience with language: object relative clauses with full noun embedded noun phrases are rare, especially when modifying animate entities. In the corpus analysis of Experiment 1, there were no examples of object relatives with an animate head noun and a full embedded NP in the spoken corpus (e.g., *The man that the woman saw*) and only 41 per million NPs in the written corpus (Table 1, full: 11 + reduced: 30 = 41). However, there were (from Table 2) 579 per million NPs animate-headed passive relatives in the written corpus. The Experiment 2 task did not promote the use of pronouns (e.g. *the ball he threw*), and so the high rate of passives in the animate condition reflects children's and adults' sensitivity to the statistics of English passive relative use in this environment. Thus, the overall high rate of passive responses, given the demands of the task, is completely predicted by the corpus analysis. Further, the observed animacy effect is also predicted, as in the corpus, object relative clauses are much more common with inanimate head nouns as opposed to animate head nouns (per million NPs, Animate head noun: 579/41 or 14 times more passive than object relatives; Inanimate head noun 2780/617 or 4.5 times more passive than object relatives in the written

corpora, and 15/29 or .5 passives for each object relative in the spoken corpus.) Thus, the corpus analysis of Experiment 1 made correct predictions for the production choices in Experiment 2. The corpus analysis predicted a higher rate of passive productions for animate targets than inanimate targets (effect of animacy) and a higher rate of passive responses for older participants or participants with greater text exposure. These predictions were indeed observed in the pattern of production responses.

Individual Differences

Group differences are consistent with an effect of text exposure on production choices, but an additional test of the hypothesis would be to find individual differences in text exposure *within* groups contributing to production choices. The title and author recognition tasks administered to participants allowed us to investigate the effect of individual differences in text exposure on production choices.

In adults, we found an effect of text exposure on utterance form. In a logistic mixed effects regression model (full model) predicting choice of object or passive relative utterance with both animacy and author recognition score, we find (obviously) and effect of animacy (z = -4.46, p < 0.001), and also an effect of text exposure (z = -2.39, p < 0.05). Individuals with higher scores on the author recognition task tended to produce more passive responses, consistent with the higher proportion of passive relatives in written language. Within passive utterances, there was no effect of text exposure on get versus be-passive use, which is not surprising given the overall low rate of get-passive use among adults.

When investigating the effect of text exposure on production choices in children, we wanted to observe an effect of text exposure beyond the effect of age. However, because age and text exposure are highly correlated (r = 0.73), we first created a model using age to predict production choices (logistic mixed-effects regression, full model), then used animacy and text exposure to predict the residuals of that model. These models employed linear mixed-effects regression with random slopes for animacy by participant and item. When predicting the choice of object or passive relative, we found an interaction between animacy and text exposure, such that individuals with more text exposure produced more passives, but only for animate targets (t = -2.63, change in model fit: p < 0.05). Within passives, text exposure predicted the choice of get or be-passive (t = 3.07, p < 0.01) such that children with more text exposure produced more be-passives. These results are consistent with the higher rate of passives, especially be-passives in written language.

Individual differences within both adults and children are consistent with the hypothesis that text exposure affects spoken language production. Differences between groups and individuals were predicted by the corpus analyses of Experiment 1, such that older individuals and individuals with more text exposure made structure choices more consistent with the distributions of written language.

Discussion

Both the group differences and individual differences are consistent with an effect of text exposure on production choices. Group differences show that passive relative use increases with age, and within passives, be-passive use increases with age. Both of these findings show that older speakers tend to more often produce the forms more characteristic of spoken language. Individual differences show that both adults and children with greater degrees of text exposure tend to produce more passive utterances. Again, text exposure is associated with a greater proportion of utterances representative of written language.

These findings shed some light on the types of changes occurring during childhood, and the types of experience that may contribute to language development. These findings is consistent with an experience-based explanation of language development and suggests that language experience through reading may be an important precursor for what is defined as adult-like language behavior in the laboratory.

General Discussion

This study investigated the relationship between children's and adults' linguistic experiences and their implicit language production choices. Experiment 1 showed that there are substantial differences in the distribution of relative clause types in child directed speech and child directed text. The existence of these differences suggest the potential for individual differences in people's language production, as production is known to reflect the linguistic environment. Specifically, we predicted that older individuals or individuals with more text exposure should produce more passive relative clauses, as these tend to be much more frequent in written language. Previous work also predicted a higher rate of be-passives in older or more literate participants, as get-passives tend to be a feature of spoken language. Our results supported these predictions. Group differences show an increase in overall passive use and be-passive use with age. Further, individual differences show an increase in passive use with text exposure (and an increase in be-passive use with age).

These results are an important first step in investigating the extent to which becoming a reader shifts people's exposure to language statistics. Subsequent work should seek to clarify these results and investigate alternative explanations. For example, individuals with more text exposure likely differ on a number of dimensions. Children who read more often may also have parents who read more often, so experiential differences may come from qualitative differences in parental speech, or a greater amount of parental speech not text exposure itself. Likewise, adults with greater text exposure may come from, or self-select themselves into contexts in which when they speak with other highly literate individuals so again, so the cause of the differences in production choices cannot be determined. That said, the consistency between the group and individual differences and the predictions derived from the corpus analysis of Experiment 1 certainly suggests that tend

exposure *could* be the causal variable, which has implications for the study of language development, and the role of literacy in language use.

An effect of written language experience on spoken language production is important for a number of reasons. First, it shows that the domains of spoken and written language may not be independent systems and experience in both domains contributes to linguistic behavior. This work highlights the differences between the statistics of written and spoken language, and suggests that learning theories of language must take into account the fact that literate individual encounter two qualitatively different sets of language statistics, and this diversity of experience likely contributes to patterns of language use in and out of the lab. Second, this work suggests a significant amount of knowledge transfer between the written and spoken language domains. The present study suggests that language behavior can be closely predicted though the experience an individual has likely encountered, and considering the dual contributions of written and spoken language experience improves those predictions. This approach blurs the line between the typically distinct notions of language acquisition, adult language use and literacy. This perspective is consistent with training studies of adults (Wells, Christiansen, Race, Acheson & MacDonald, 2009) that suggest that language behavior changes with experience, well into adulthood. The onset of literacy in childhood, not any particular domain-general cognitive development, may be an important predictor of what might have otherwise been considered language development, as children are exposed to a new set of linguistic patterns with the onset of literacy. Further, text exposure, through reading, across the lifetime continues to provide linguistic experience, qualitatively different from that of spoken language, that continues to account for individual differences into adulthood.

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