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Repetition reduction: Lexical repetition in the absence of referent repetition

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Abstract

Repeated words are produced with reduced acoustic prominence compared to words that are new to a discourse. Although these effects are often attributed to priming in the production system, the locus of the effect within the production system remains unresolved because in natural speech, repetition often involves repetition of referents and lexical items simultaneously. Therefore, repetition reduction could be due to repeated mention of a referent, or repetition of a word or referring expression. In our study, we test whether repetition reduction is due to repetition of lexical items or repeated mention of referents using an event description task. The results show that repeated lexical items lead to reduced duration and intensity even in the absence of referent repetition whereas repeated referents lead to reduced intensity alone. The general pattern suggests that repetition reduction is due most strongly to repetition of the lexical item, rather than repeated mention of the referent.

Keywords

prominence; repetition; prosody; reference; lexical retrieval; speech production

There is a wealth of evidence showing that repeated words are produced with reduced prominence (Aylett & Turk, 2004; Bard & Aylett, 1999; Bard et al., 2000; Bell et al., 2009; Fowler, 1988; Fowler & Housum, 1987; Galati & Brennan, 2010; Jurafsky et al., 2001; Lam & Watson, 2010). Some have argued that this effect is due to the predictability of repetition (Aylett & Turk, 2004; Fowler 1988; Fowler & Housum, 1987; Heller & Pierrehumbert, 2011; Jurafsky et al., 2001). In natural language, repetition is predictable (Arnold, 1998). A previously mentioned referent is more likely to be mentioned in the following utterance than a new referent. Similarly, repetition of words themselves is also predictable. Once a word has entered the discourse, the probability of reuse is higher than the word's lexical frequency (Heller, Pierrehumbert, & Rapp, 2010). According to predictability accounts of repetition reduction, speakers can afford to reduce prominence for repeated words because they are predictable or redundant. Others have argued that this effect is due to the speaker's internal

production system (Bell et al., 2009; Galati & Brennan, 2010; Kahn & Arnold, 2012; Lam & Watson, 2010). In particular, this view argues that words that are retrieved more easily are produced with reduced prominence. On this view, repeated words are reduced because lexical retrieval for repeated words is easier for the production system than lexical retrieval for words that are new to a discourse. These two accounts are not necessarily incompatible and some studies have shown reduction effects that are consistent with both accounts (e.g. Kahn & Arnold, 2012; Lam & Watson, 2010). In this paper we focus on the mechanics of the production-centered view.

According to most theories of lexical access (e.g. Dell, 1986; Levelt, Roelofs, & Meyer, 1999), a speaker must first access the lemma representing a particular word and then retrieve the individual phonemes associated with that lemma (i.e. the lexeme). This may be easier when the word has been previously mentioned because representations at both of these levels are likely to be primed. When a speaker must refer to an entity that has not been previously mentioned, generating the referring expression is more effortful because the lemma and phonological representations are not primed (Bell et al., 2003; Bell et al., 2009; Chang, Dell, & Bock, 2006; Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Griffin & Bock, 1998). As a result, a speaker may require more time to retrieve a word that is new to the discourse. Even following lemma access, production may require additional time to access individual phonemes according to their serial ordering (Dell & O'Seaghdha, 1992; Sevald & Dell, 1994). However, a repeated word will have been previously activated and may be less difficult to retrieve than when it was first mentioned. As a result, the individual phonemes may be retrieved more quickly, leading to shorter durations.

A study by Galati & Brennan (2010) provides some support for this view (see also Meagher & Fowler, in press). In their experiment, participants watched a video clip and then described the events of the clip twice. Participants either described the same event two times to the same person, or one time to one person and a second time to a different person. Interestingly, words produced for different listeners were rated as more intelligible than words produced for the same listener. However, they also found that speakers always reduced the duration of critical words when retelling the story, regardless of whether the listener was the same listener or a different listener.

While there is evidence supporting a processing-centered view of repetition reduction, there is some ambiguity as to what it means to be repeated. Repetition can mean a number of different things. It can include repeatedly mentioning the same referent, as in the case of pronoun use, or it could refer to the repetition of a lexical item: repeatedly using the same word. This question is of particular interest because it may reveal details about how prosodic prominence is represented in the production system. Repetition reduction could be due to repetition at the message level, such as repeated mention of a particular referent. Repetition reduction could also be due to repetition at the level of lexical selection such as repeatedly accessing a specific word or referring expression. Finally, reduction could be due to repeatedly articulating the same phonetic form.

In a previous study, Fowler (1988) argued that the repetition effect is likely rooted at the message or discourse level of production. In her study, she asked participants to read aloud

paragraphs that contained critical words. Before the target sentence, participants read a sentence that contained either a previous mention of the target word, a homophone of the target word, or an unrelated word. She found that while repetition of the same word led speakers to shorten duration, words that were preceded by a homophone were not produced with shorter duration. This pattern suggests that simply repeating the articulatory pattern for a word is not enough to lead to reduced prominence. However, there are reasons to question this claim. First, no inferential statistics were provided that would indicate whether or not there were reliable differences in the reduction of targets preceded by homophones versus those preceded by an identical lexical item. Second, targets were not normed for frequency, and more recent work suggests that repetition of high frequency words lead to greater reduction (Baker & Bradlow, 2009).

A study by Kahn & Arnold (2012) provides some evidence that linguistic repetition may play a privileged role in reduction. In their study, participants described an object undergoing a change. The object was either new, linguistically given (previously mentioned), or non-linguistically given (visually cued but not previously mentioned). They showed that both linguistically given and non-linguistically given words are produced with reduced prominence, however linguistic givenness leads to greater reduction than non-linguistic givenness.

Work in syllable production also suggests that linguistic repetition may play a key role in a speaker's production choices. Sevald & Dell (1994) found that in a word repetition task, speakers were faster at repeating TICK-PICK than PIN-PICK. They argued that an interactive, serial phonological encoding system might explain these differences. When the onset of the words overlap, feedback to lemma levels from the phonological encoding system creates lexical competition between the two words that lasts through the entirety of the word, slowing speakers down. In contrast, when the rhyme of the two monosyllables overlap as in TICK PICK, competition does not occur until the words are almost complete, resulting in less production difficulty. This work suggests that there is a link between duration and phonological encoding, though critically, it depends on a phonological encoding system that is serial. Jaeger, Furth, & Hilliard (2012) have found similar effects of phonological overlap on lexical access, and Buxo-Lugo, Simmons, & Watson (2013) found that a simple recurrent network designed to simulate a serial phonological encoding system accurately predicted reduction in speakers. These studies suggest that linguistic repetition may play a privileged role in determining reduction and may have more impact on duration than other types of repetition.

It is also possible that these different types of repetition may affect prominence in different ways. This would be consistent with what Watson (2010) calls a multiple source theory of prominence. According to Watson (2010), prominence is best explained as the result of a combination of effects from multiple sources instead of a single source. According to the multiple source view of prominence, factors that are typically correlated in natural speech may have independent effects on prominence and may affect the acoustic signal in different ways. There is empirical evidence that such a model is warranted (Lam & Watson, 2010; Mahrt, T., Cole, J., Fleck, M., Hasegawa-Johnson, M., 2012; Watson, 2010; Watson, Arnold, & Tanenhaus, 2008). For example, Lam & Watson (2010) showed that while repetition and

predictability are correlated in natural speech, predictability is more strongly linked to changes in intensity whereas repetition is more strongly linked to changes in duration. Similarly, Mahrt et al. (2012) present modeling evidence from corpora that suggests that F0 and intensity are best modeled as binary predictors of prominence whereas duration is a best modeled as a continuous predictor of prominence. Thus, under a multiple source account of prominence, referent repetition and lexical repetition may both affect prominence, but affect different aspects of the acoustic signal.

The goal of this paper is to determine whether lexical repetition plays a central role in reduction. If the mechanics of lexical and phonological production are linked to duration, repetition of a referring expression should lead to reduction, independent of whether it refers to the same referent in the discourse. Attaching a given name to a new referent should still lead to reduction. We test this prediction below. We also explore whether repetition of other aspects of linguistic structure, in particular referential repetition, plays a role in reduction.

Experiment 1

In this study, we explored the repetition effect by testing whether repetition reduction is affected by repetition of a word (lexical repetition), independent of the intended referent. Speakers described two events involving different characters with different occupations moving between locations on a computer screen. Sometimes the same character was mentioned twice. Other times, one character was mentioned and then a different character was mentioned. Additionally, sometimes the two events involved characters that were either described with the same referring expression or with different referring expressions.

Method

Participants

Sixteen people participated in this study. Participants were a mix of subject pool participants from the University of Illinois and paid participants living in Champaign or Urbana, Illinois. Participants recruited from the subject pool were compensated with course credit in exchange for participation. Paid participants were compensated \$8 for one hour of participation. All participants were native speakers of American English with normal or corrected to normal vision and hearing.

Materials

In order to create a context in which the same referent could be referred to using different referring expressions, we created an event description task in which participants described images of characters that were training for different occupations at two different training centers. The occupations of the characters on the screen were all identifiable from their clothing. Participants were told that the training centers were the “University of Illinois” and “Parkland College”. Both of these are the names of real-life institutions located in the Champaign-Urbana area.

The images used in this experiment were created using the Sims creator from The Sims 3 ©, a video game. We created 14 different characters with varying physical characteristics. The

characters that were created differed in skin color, age, facial hair, gender, and ethnicity to maximize their distinctiveness for participants. (See Appendix A for examples of the character images used in this study.)

There were two factors: repetition of characters and repetition of occupations (lexical repetition). This yielded four conditions: non-repeated character, non-repeated occupation; non-repeated character, repeated occupation; repeated character, non-repeated occupation; repeated character, repeated occupation (See Figure 1 for an example display of each condition). The four conditions were counterbalanced in a Latin square design across four lists of trials. There were a total of 16 critical items (occupation names). In order to increase statistical power, items were repeated over the course of the experiment such that each occupation was used two times as a critical word, but appeared in different conditions across the two encounters. As a result, we also tracked the number of times in which the participant encountered a particular occupation as a critical target (we term this variable “encounter”). The encounter manipulation was hidden from the participants.

Images were displayed using Matlab with the Psychophysics Toolbox version 3. At the beginning of a trial, participants saw an area labeled University of Illinois on the left side of the screen and a grey, “home” area on the right side of the screen. In the area labeled University of Illinois, participants initially saw two characters with different uniforms. Then, one of these characters moved to the home region. Participants described this leaving event by saying, for example, “The doctor is leaving Illinois.” Then the screen scrolled to the right so that Parkland College was now visible and the University of Illinois was no longer in the display. The “home” area, which was positioned half way between the two training centers, remained visible throughout the trial. The Parkland College training center contained a third character. On half of the trials, the character at “home” moved to Parkland College while wearing the same outfit s/he was wearing at the University of Illinois. Then one of the two characters at the Parkland College training center moved off screen. The participant then described this second leaving event. On the other half of trials, the character at “home” briefly disappeared and reappeared on screen in a different uniform before moving to Parkland College. Then, one of the two characters at Parkland College moved off screen. The sequence of events is depicted in Figure 2. The types of sentences produced in each condition are presented in (1a-1d).

(1a) Non-repeated character, non-repeated occupation: “The doctor (man 1) is leaving A. The detective (man 2) is leaving B.”

(1b) Non-repeated character, repeated occupation: “The detective (man 1) is leaving A. The detective (man 2) is leaving B.”

(1c) Repeated character, non-repeated occupation: “The doctor (man 2) is leaving A. The detective (man 2) is leaving B.”

(1d) Repeated character, repeated occupation: “The detective (man 2) is leaving A. The detective (man 2) is leaving B.”

Note that participants were explicitly told in the instructions that the person who moved to the home area may or may not change clothing for a new occupation before moving to

Parkland College. Consequently, participants were aware that the person entering and leaving the home was the same character. The detailed instructions are presented in (2) below.

- (2) During the next part of the experiment you will see simple scenes of characters who are training for different occupations. There are two training centers, one at the University of Illinois and one at Parkland College. Your job will be to name the person who is leaving each training center by using his/her occupation name. When the first screen appears you will see the two training centers as well as two people who are at Illinois. Press any key and one of these two people will leave the Illinois training center and go home to the middle area. You are to describe this event by saying, “the [occupation name] is leaving Illinois.” After describing the first event, press any key to continue. At this point, the screen will scroll over. The person who went home will leave his/her house and head to the Parkland training center. Sometimes the person who left Illinois for Parkland is training for a different job at Parkland and will change outfits. Once the person has moved to the Parkland training center, press any key to make one of the two people at Parkland leave. You will then describe the person who is leaving Parkland by saying, “the [occupation name] is leaving Parkland.” After describing the second leaving event, you may press any key to move on to the next trial.

Procedure

Because some of the occupations were more readily identifiable through uniforms than others, participants were trained on the names of the 16 occupations before beginning the experiment. During training, participants were shown a picture of a character wearing his or her occupation's uniform. The occupation name was displayed below the picture. Participants were required to say the occupation name aloud. After naming all of the occupations once, they were presented with test trials in which the image was displayed without the occupation name. Participants were again required to name the images. If the participant had forgotten the name, the experimenter gave the participant the name. There was no interlocutor present. Although it is clear that speakers modulate how acoustic prominence is produced based on their audience and task goals (see Buxo-Lugo, Toscano, & Watson, 2013; Lam, 2012; Rosa et al., in press), previous work from our lab suggests that repetition leads to reduction, regardless of whether a speaker is present or not (Lam & Watson, 2010). Moreover, other work suggests that speakers reduce referring expressions regardless of whether or not the addressee has changed (Bard & Aylett, 2005; Galati & Brennan, 2010; Meagher & Fowler, in press).

Following the name training, participants were presented with four practice trials, one from each condition. Following the practice trials, participants completed 32 critical trials. There were no filler trials. Participant descriptions were recorded using a microphone headset. The microphone was positioned at a constant distance from the mouth of the speaker in order to accurately measure the intensity of the sound wave. Analyses were conducted on the average intensity and duration values of the target word, which was the occupation name in the second utterance on each trial.

Norming study

In a typical discourse, a pronoun is used to refer to a previously mentioned entity; however, in the current study, participants were instructed to use full referring expressions in both descriptions. The use of the same referring expression across two sentences (e.g. “The doctor is leaving Illinois. Now the doctor is leaving Parkland.”) is infelicitous under some frameworks (e.g. Gordon, Grosz, & Gilliom, 1993). In addition, it may be pragmatically odd for speakers to describe the same person using two different labels (as in the repeated character, non-repeated occupation condition). Previous work suggests that once interlocutors entrain on a lexical term, the introduction of a new term causes processing difficulty (Metzing & Brennan, 2003). Also, in the condition in which two different characters are referred to with the same label, a natural response for speakers might be to disambiguate which character is being referred to in the second instruction. Finally, in the repeated character, non-repeated occupation condition, a felicitous response might include mention of the occupation change.

To address concerns related to how natural the target productions were, we conducted a separate norming study (N=10) to determine how participants described the leaving events when not given explicit instructions to use occupation names. Participants were told only to describe the movement of the characters leaving the training centers. Response patterns for the norming study are presented in Table 1.

To determine whether the target constructions in this study were reasonably felicitous, we considered a) whether participants always felt compelled to disambiguate which character they were referring to (for characters sometimes shared occupations across the events) b) whether participants always mentioned occupation changes when they occurred and c) whether participants ever produced two full referring expressions in a row (as opposed to a pronoun). The experimental target constructions did not include referential disambiguation or pronouns, and the instructions to participants did not include mention of occupation changes if they occurred. If participants in the norming study spontaneously produce at least some discourses that share these properties with the target constructions, we can conclude that the target constructions are not entirely infelicitous. As shown in Table 1, in all conditions, participants in the norming study produced at least some utterances that were similar to the scripted instructions for Experiment 1 (See Appendix B for sample constructions used by the participants). The overall pattern of responses suggests that in the contexts of our norming study, subjects spontaneously produced referring expression that were quite similar to the constructions used in our experimental task. We believe that given the constraints of the task and the salience of the occupations, the discourses used in the study were acceptable.

Predictions

If repetition reduction arises from repetition of the character, independent of the referring expression used, then even when the occupation name has changed, repeated characters should be produced with less prominence than non-repeated characters. If repetition reduction is due to repetition of the referring expression (i.e. lexical repetition), then repeated occupation names should lead to reduction, even when the character has changed.

Additionally, it may be possible that both kinds of repetition lead to reduction independently. This would be consistent with a multiple source account of prominence (Watson, 2010).

Results

Approximately 5.5% of trials (28/512) were discarded because participants either misnamed the target or used a pronoun to describe the target. Details of data loss by conditions are presented in Table 2.

Prominence data were extracted from target words (the occupation name in the second utterance) using Praat, a speech analysis platform (Boersma & Weenink, 2007). The focus of this paper is examining the mechanisms underlying reduction, so this data was initially analyzed with the goal of understanding differences in target word duration. However, as will be seen below, speaker intensity was affected by the manipulation, so we include these data as well.

Results were analyzed with multilevel linear mixed effects models with fixed effects of character repetition, lexical repetition, and encounter (i.e. the number of times in which the participant encountered a particular occupation as a critical target). Character repetition and lexical repetition were both contrast coded and encounter was centered. The random effects structure was determined by backwards model selection starting with the maximally complex random effects structure (i.e. random slopes of each fixed effect) for both subjects and items (Barr, Levy, Scheepers, & Tily, 2013). Using backwards model selection, it was determined that the best random effects structure included only random intercepts with no slope terms, and we will be reporting only effects from this model; however, all reported significant effects were also significant in the maximal random effects structure that reached convergence. For duration, the maximally converging random effects structure included slopes of lexical repetition, character repetition, encounter, and the interaction between lexical repetition and character repetition for subjects and random slopes of lexical repetition, character repetition, and encounter for items. For intensity, the maximally converging random effects structure included slopes of lexical repetition, character repetition, encounter, and the interaction between character repetition and encounter for subjects and slopes of lexical repetition, character repetition, encounter, the interaction between lexical repetition and encounter, and the interaction between character repetition and encounter for items. Reported p-values were obtained by normal approximation by assuming that the t-distribution approached a z-distribution given our number of observations. Raw durations were measured in milliseconds and intensity was measured in decibels.

The duration data are shown in Figure 3. For duration, there was a main effect of lexical repetition such that repeated lexical items had shorter durations than non-repeated lexical items ($\beta=36.34$, $SE=9.879$, $t=3.679$, $p<0.001$). There was no reliable interaction between lexical repetition and character repetition ($\beta=-13.737$, $SE=9.998$, $t=-1.374$, $p>0.10$). This is consistent with the notion that repeating a word leads to reduction, even when it is paired with a new referent.

In contrast, there was no significant main effect of character repetition on duration ($\beta=-3.466$, $SE=4.998$, $t=-0.694$, $p>0.10$), but there was a significant main effect of encounter such that occupation names were produced with shorter duration on the second encounter ($\beta=-21.66$, $SE=7.661$, $t=-2.827$, $p<0.01$). In addition, there was a three-way interaction between lexical repetition, character repetition, and number of encounters ($\beta=48.49$, $SE=20.00$, $t=2.425$; $p<0.05$), such that for the first encounter, reduction due to lexical repetition was greater when the character was repeated than when it was not repeated ($\beta=-35.25$, $SE=15.22$, $t=-2.32$, $p<0.05$). This was not true for the second encounter ($\beta=9.50$, $SE=13.92$, $t<0.682$, $p>0.10$).

The intensity data are presented in Figure 4. As with duration, there was a significant main effect of lexical repetition on intensity such that repeated lexical items led to lower intensity ($\beta=0.6684$, $SE=0.1845$, $t=3.62$, $p<0.001$), but there was no main effect of character repetition ($\beta=0.08021$, $SE=0.18449$, $t=0.43$, $p>0.10$). In contrast to the duration results, there was no main effect of the number of encounters (-0.06646 , $SE=0.18446$, $t=-0.36$, $p>0.10$). However, there was a three-way interaction between lexical repetition, character repetition, and encounter for intensity, though the pattern of the interaction was different from that of duration ($\beta=-1.781$, $SE=0.7383$, $t=-2.41$, $p<0.05$). On the first encounter, there was a significant interaction between character repetition and lexical repetition ($\beta=1.202$, $SE=0.5252$, $t=2.29$, $p<0.05$): in the non-repeated character conditions, if the lexical item was repeated, then it was reduced in intensity compared to when the lexical item was not repeated, but when the character was repeated, there was no effect of lexical repetition. On the second encounter, this interaction was not reliable ($\beta=-0.6799$, $SE=0.4936$, $t=-1.38$, $p>0.10$).

Discussion

In Experiment 1, we found that lexical repetition was the primary determinant of prominence reduction. For both intensity and duration, repeated lexical items led to reduced prominence. The results are less clear for character repetition. While character repetition seemed to affect prominence, it interacted with both lexical repetition and the number of times the word had been encountered in the experiment. For duration, repetition effects were larger when the character was repeated compared to when the character was not repeated, but only on the first encounter. This interaction is explored in Experiment 2.

There was also a three-way interaction between lexical repetition, character repetition, and encounter for intensity. On the first encounter, repeated lexical items were produced with lower intensity than non-repeated lexical items, but only in the non-repeated character condition. There was no effect of lexical repetition in the repeated character condition. However, by the second encounter, the repeated character, repeated occupation condition was produced with lower intensity than the repeated character, non-repeated occupation condition. One possible explanation for this effect is that some participants may have initially had difficulty using occupation names to refer to repeated characters. In the norming data, 50% of participants chose to use pronouns when referring to repeated characters. Consequently, in the repeated character, repeated occupation condition, there may have been difficulty associated with producing a full referring expression when a

pronoun was preferred. An increase in intensity due to this production difficulty might have offset any effect of character repetition. If this is true, participants who are given enough trials to adjust to the statistics of the experiment, may show an effect of both character and lexical repetition in later trials.

In conclusion, this experiment supports the hypothesis that repetition reduction is driven primarily by lexical repetition. This effect could be due to the ease of retrieving a previously retrieved lexical item or due to some process that occurs after lexical retrieval (e.g. repetition of articulatory gestures). Additionally, the experiment leaves open the possibility of some contribution from character repetition, at least for intensity. However, the character repetition effect is relatively weak and may have been obscured in earlier trials due to processing difficulty associated with using occupation names (rather than pronouns) to refer to previously mentioned characters. We conducted Experiment 2 to address the issue of whether character repetition effects may arise after participants have accommodated to using occupation names rather than pronouns to refer to repeated characters.

Experiment 2

The purpose of Experiment 2 was to determine whether character repetition would lead to a reduction in intensity if participants were given enough exposure to critical trials. Experiment 2 was identical to Experiment 1 except that it included 16 more trials.

Method

Participants

Participants had the same characteristics as in Experiment 1. Thirty-three people participated in Experiment 2. Data from seven participants were excluded from analysis: Four participants failed to follow the instructions leading to unanalyzable data, one participant was excluded because of a sound equipment failure, one participant was not a native speaker of American English, and finally one participant had a cold and coughed during the experimental trials.

Materials

The materials were identical to Experiment 1 except that each occupation name was used three times instead of two, yielding a total of three encounters. All other factors were identical to those of Experiment 1.

Procedure

The procedure was identical to that of Experiment 1, except that there were 16 additional trials for a total of 48 trials.

Results

Approximately 2.5% (31/1248) of trials were unanalyzable because participants either misnamed the target or used a pronoun in referring to the target. Details about data loss by conditions are presented in Table 3.

As in Experiment 1, results were analyzed with multilevel linear mixed effects models with character repetition, lexical repetition, and encounter as fixed effects. Character repetition and lexical repetition were both contrast coded and encounter was centered. The random effects structure was determined by backwards model selection starting with the maximally complex random effects structure (i.e. random slopes of each fixed effect) for both subjects and items. For both duration and intensity, the best fitting model according to backwards selection included random intercepts for subject and items as well as a random slope term of encounter for subjects suggesting that some subjects were more strongly affected by encounter than other subjects. All reported significant effects were also significant in the maximal random effects structure that reached convergence. For duration, the maximally converging random effects structure included slopes of lexical repetition, character repetition, encounter, and the interaction between lexical repetition and character repetition for subjects and random slopes of lexical repetition, character repetition, encounter, and the interaction between character repetition and encounter for items. For intensity, the maximally converging random effects structure included slopes of lexical repetition, character repetition, encounter, the interaction between lexical repetition and character repetition, and the interaction between lexical repetition and encounter for subjects and slopes of lexical repetition, character repetition, encounter, and the interaction between lexical repetition and character repetition for items. Reported p-values were obtained by normal approximation by assuming that the t-distribution approached a z-distribution given our number of observations. Data analysis for duration was conducted on raw durations whereas analysis for intensity was conducted on decibels.

Figures 5a-5c present the duration data across all three encounters. There was a significant effect of lexical repetition for duration such that repeated lexical items were produced with shorter duration than non-repeated lexical items ($\beta=24.25$, $SE=2.806$, $t=8.641$, $p<0.0001$). However unlike in Experiment 1, the three-way interaction between character repetition, lexical repetition, and encounter was not significant ($\beta=-11.09$, $SE=6.869$, $t=-1.615$, $p>0.10$). We return to this in the General Discussion. Additionally, there was no effect of character repetition on duration nor was there a significant interaction with lexical repetition or with encounter.

Figures 6a-6c present the pattern for intensity data across all three encounters. As in Experiment 1, there was a main effect of lexical repetition such that repeated lexical items were produced with lower intensity ($\beta=0.2989$, $SE=0.1091$, $t=2.74$, $p<0.01$), but there was no main effect of character repetition. Unlike Experiment 1, the three-way interaction between lexical repetition, character repetition, and encounter was not significant ($\beta=-0.05814$, $SE=0.2669$, $t=-0.22$, $p>0.10$); however there was a significant two-way interaction between character repetition and encounter. Speakers initially produced repeated characters with greater intensity than non-repeated characters, but produced repeated characters with less intensity than non-repeated characters by the third encounter ($\beta=0.3080$, $SE=0.2669$, $t=2.31$, $p<0.05$). This pattern is depicted in Figure 7. On the first encounter, repeated characters were produced with numerically greater intensity than non-repeated characters but this effect was not reliable ($\beta=-0.2931$, $SE=0.1939$, $t=-1.51$, $p>0.10$). On the second encounter, repeated characters were produced with numerically lower intensity than

non-repeated characters but this effect was also not reliable ($\beta=0.1794$, $SE=0.1874$, $t=0.96$, $p>0.10$). On the third encounter, repeated characters were produced with numerically lower intensity than non-repeated characters and this effect approached significance ($\beta=0.3104$, $SE=0.1863$, $t=1.67$, $p=0.096$).

Discussion

In general, Experiment 2 replicated the results from Experiment 1. As in Experiment 1, there was a strong effect of lexical repetition: repeated lexical items led to shorter durations and lower intensity regardless of whether or not the character was repeated. Because repeated lexical items led to reduction irrespective of whether the character itself was repeated, it suggests that this effect is the result of processes at the level of lexical access, and not at the level of the referent.

The data also suggest that the effect of repetition on reduction is not strongly linked to repeated mention of characters. While character repetition did affect prominence, it did so only for intensity. Moreover, the effect only appeared towards the end of the experiment (i.e. the second and third encounter). As previously mentioned, this effect may be due to processing difficulty associated with using occupation names to refer to repeated characters. Initially, participants may have had difficulty using occupation names to refer to repeated characters, which may have offset any effect of character repetition, but over the course of many trials, they accommodated to this experimental constraint (for similar effects in the domain of syntactic parsing, see Fine & Jaeger, 2013; Fine, Jaeger, Farmer, & Qian, submitted; Jaeger & Snider, 2013) thereby reducing the intensity of repeated characters even when different occupations names were used. Note that this effect differs slightly from that of Experiment 1. In Experiment 1, there was a three-way interaction between lexical repetition, character repetition, and encounter, while in Experiment 2 the three-way interaction was not reliable. Instead there was a two-way interaction between character repetition and encounter. Although there are some differences between the results of Experiment 1 and Experiment 2, there is reason to believe that the three-way interaction in Experiment 1 was spurious. Experiment 2 had more power than Experiment 1 because the latter had more subjects (26 vs. 16) and more trials (48 vs. 32). Moreover, a combined analysis including both experiments showed a two-way interaction between character repetition and encounter ($\beta=0.3105$, $SE=0.1554$, $t=2.00$, $p<0.05$), suggesting that only the two-way interaction is robust.

One potential concern is whether the reduction effects in the lexical repetition condition are reliable given the potential for changes in speakers' construction preferences over the course of the experiment. However, it is striking that reduction due to lexical repetition is robust in both Experiments 1 and 2, and occurs independent of whether the same character is referred to across mentions within a trial and independent of trial location in the experiment. This suggests that although expectations might shift across the experiment, they have little effect on reduction due to lexical repetition, as would be predicted in an account in which reduction is linked to lexical level processes.

General Discussion

The data from Experiment 1 & 2 suggest that repetition reduction is primarily due to repetition of lexical items. Referring expressions that were repeated tended to be reduced in duration, even when the referring expression referred to a new character. This is consistent with the notion that priming at lexical or phonological stages of encoding may lead to reduction in duration. The system needs less time to plan a repeated word, and consequently, its duration is shorter than it would be if the word was articulated for the first time.

One open question is whether the repetition effect seen here results from repetition of the lemma or repetition of the phonological form. Fowler (1988) argued that repetition of phonemic form is not enough for reduction because homophone primes did not lead to reduced duration in her study, though these findings are not definitive. As discussed in the introduction, some changes in word duration have been linked to phonemic encoding (Buxo-Lugo et al., 2013; Sevald & Dell, 1996). On the other hand, there is evidence that at least some aspects of repetition reduction are linked to the lemma. When homophones such as “time” and “thyme” are repeated, the amount of duration reduction is predicted by the frequency of the lemma, which is the abstract lexical concept, not frequency of the lexeme, which is the phonemic form (Gahl, 2008). It is possible that both lemma and phonological repetition affect repetition reduction, and future work will need to explore the extent to which these types of repetition contribute to reduction.

These data also suggest that reduced prominence is only weakly linked to repetition of characters. While character repetition also seemed to affect prominence, it did so only for intensity. Moreover, the effect was only present on later trials. This would suggest that other forms of repetition, such as referential repetition, play a less central role in reduction than lexical repetition.

Of course, the above conclusion depends on a null result, so it is possible that some aspect of the experimental design led to character repetition being less important for reduction than lexical repetition. For one thing, because a central component of the task was describing the names of occupations, listeners might not have paid attention to character identities. This could have been because the characters were not discriminable or because participants did not need to track characters across events to complete the task or because character identity was not emphasized in the instructions. With respect to the first concern, the characters differed along dimensions of ethnicity, gender, race, as well as facial characteristics (see Appendix A), so we suspect that participants were able to identify characters across events. Further evidence for this comes from the data: if participants were unable or unwilling to track the characters across events, there would not have been effects of character repetition on intensity in later experimental trials. Finally, when we do see effects of character repetition in the later trials, the effects appear only on measures of intensity, not measures of duration. Thus, although it is possible that some aspect of the task made the characters less salient to participants, the data suggest that character repetition plays less of a role in determining duration than lexical repetition.

Another concern is that the lack of a character repetition effect on duration may have been the result of infelicity in certain conditions. Although the norming study suggested that participants spontaneously produced constructions like the target sentences used in this experiment, it is still possible that certain conditions were less felicitous than others. In particular, referring to a mentioned referent with a new name may be associated with increased processing difficulty. Referring expressions often reflect how a referent is conceptualized (e.g. Brennan & Clark, H. H., 1996; Clark, E. V., 1996). It is possible that the label change in the repeated character, non-repeated occupation condition may have required updating the semantics of the repeated referent, resulting in a processing cost. It might also be the case that using a new name for a repeated referent is infrequent in real-life discourse and doing so in the experiment led to processing difficulty. Consequently, difficulty for either of these reasons could have led to lengthening, which would have negated any reduction associated with character repetition.

Although previous work has demonstrated that using a new referring expression to refer to a given referent when a referring expression has already been established can lead to processing difficulty for listeners (Metzing & Brennan, 2003), this renaming of a referent is not necessarily infelicitous, particularly when the new referring expression conveys additional information (Almor, 1999). In his Information Load Hypothesis, Almor (1999) argues that a change of referring expression that increases information load can be justified when the increase in load helps to identify the referent or adds new information. Similarly, Clark & Wilkes Gibbs (1986) point out that a speaker can use “expanded noun phrases,” instances in which the speaker changes course or decides that a previous referring expression is insufficient for conveying a concept. Consider (3), (4), and (5) where bold-face referring expressions share a common referent:

- (3) The account that emerged on Wednesday suggests that Mr. Weiner's interactions with **the woman, a partisan Democrat from Indiana who thought of him as a hero**, fit his longstanding pattern. (From the New York Times article “Account of Weiner's Online Exchanges Fit Pattern, July 24, 2013)
- (4) In the linguistics-psychology basketball pickup game, Julie the **phonologist** switched to the psychology team. The psychologists were happy to get **the best point guard on the court**.
- (5) “Among those competing for a roster spot at the Golden State Warriors training camp, none may be more proud to wear the jersey than **Bay Area native Jeremy Lin**...[5 second clip of Lin speaking]... **The twenty-two year old rookie point guard** signed with the Warriors this summer after going undrafted. (From a 2010 Associated Press news report on YouTube)”

Although Clark & Wilkes-Gibbs used the term expanded noun phrase to describe instances in which listeners add additional information to referring expressions within a constituent as in (3), examples (4) and (5) suggest that this can occur across sentences (e.g. “the phonologist” and “the best point guard” refer to the same person), just as in our experimental sentences. This appears to be true in spoken references as well as written

references as demonstrated in (5). Thus, using multiple referring expressions, particularly when they provide new information, is not infelicitous.

A related concern is that referring to a referent with multiple referring expressions is relatively low in frequency (or is low in felicity without being completely infelicitous), and this may have led to lengthening, which is often correlated with infrequent linguistic structures (e.g. Gahl & Garnsey, 2004; Aylett & Turk, 2004; Jaeger, 2010). This lengthening may have obscured any effects of repeating the character. Although 50% of the participants spontaneously used two different definite noun phrases to refer to the target in the repeated character, non-repeated occupation condition, it is possible that the discourse contexts themselves are relatively rare. One prediction of such an account is that there should be an interaction between character repetition and lexical repetition in these experiments. That is to say, although referring to a repeated character with a new referring expression should be difficult (and should possibly pattern with the new occupation conditions, leading to longer durations), referring to a given character with the same referring expression should be the easiest to produce, leading to the shortest duration. This would be true because in the latter condition, the speaker would benefit from both a repeated lexical item and a repeated character, which would result in more reduction than if either one of these factors alone were present. Such an interaction is not consistently present in the data. Looking more closely at the data patterns, this interaction is reliable in Experiment 1 for the first encounter (see Figure 3a), but it is not reliable in the second encounter (see Figure 3b), nor is it reliably present in any of the encounters in Experiment 2. Finally, if the frequency of this discourse construction was attenuating effects of character repetition, one might expect similar attenuation in the condition in which a new referent is referred to by a previously established referring expression, for both are likely to be low in frequency. Instead, we see reduction in both lexical repetition conditions, suggesting that even if there are relative differences in the frequencies or difficulties across conditions, the task is sensitive enough to detect effects of repetition. The robustness of the lexical repetition effect suggests that it plays a key role in reduction.

In conclusion, this experiment supports the idea that repetition reduction is driven primarily by lexical repetition. Additionally, these results leave open the possibility for some contribution from character repetition, at least for intensity. However, the character repetition effect is relatively weak. In addition, repeated characters were produced with reduced intensity but not reduced duration whereas repeated lexical items led to reduction in both duration and intensity. This pattern suggests a dissociation between duration and intensity in how they are affected by different types of repetition. Dissociations between duration and intensity are not without precedent (e.g. Lam & Watson, 2010; Watson, Arnold, & Tanenhaus, 2008). For example, Watson, Arnold, & Tanenhaus (2008) showed that importance influences intensity whereas predictability influences duration. This pattern is consistent with the multiple source account of prominence (Watson, 2010), which argues that prominence effects are best explained as arising from a combination of separate factors rather than from a unitary source.

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Appendix A

Below we present a sample of the images used in the study grouped by character. The full set of images (9 men, 5 women) is available from the first author upon request. The images below are presented in the same size as seen in the actual study.

Appendix B

In the norming study, we were concerned with whether the target constructions used in this experiment were felicitous. In a more natural context, participants would likely disambiguate which character they were referring to when two characters had similar occupations at some point in the trial. They might mention the wardrobe change, and they would likely use a pronoun to refer to a previously mentioned character. Our target sentences did not include disambiguation or mention of the wardrobe change, and required productions of full referring expressions. Thus, the goal of the norming study was to explore whether participants ever produced constructions like the target sentences. Below are some sample productions.

In the non-repeated character, repeated occupation condition, two potential characters could be the referent of the occupation name in the critical leaving event description. We found that seven out of ten participants did not disambiguate which character was being referred to in the second instruction. Below are example spontaneous productions from the non-repeated character, repeated occupation condition. These are cases in which the speaker does not make the target character clear:

(B1) “The nurse goes home. And then goes to conductor training at Parkland. And the nurse leaves the training center.

(B2) “Doctor goes home. Astronaut goes to Parkland. Doctor leaves Parkland.”

It is also the case that participants did not always mention the occupation change. In the repeated character, non-repeated occupation condition, which is the condition in which this concern is most relevant, the majority of participants mentioned the change (eight out of ten), but not always (see examples B3 and B4).

(B3) “So the pilot goes home. The detective goes to Parkland. Detective leaves Parkland.

(B4) “The paramedic went home. And the scientist went to Parkland. And scientist left Parkland.”

Next, we were concerned that speakers might always prefer to produce a pronoun in the repeated character, repeated occupation condition. We found that five out of ten participants produced sentences like (B5) while the other five participants used pronouns to refer to the character in the second utterance (B6).

(B5) “A pilot leaves Illinois goes home. The pilot leaves home goes to Parkland. The pilot leaves Parkland.”

(B6) “The astronaut goes home. She goes to Parkland and then leaves Parkland.”

Finally, in the non-repeated character, non-repeated occupation condition, all ten participants produced sentences similar to Example 2. (B7) and (B8) are examples of responses in the non-repeated character, non-repeated occupation condition.

(B7) “Paramedic goes home. And goes to the training center at Parkland. And the astronaut leaves the training center.”

(B8) “Detective goes home. Detective goes to Parkland. The maid leaves Parkland.”

Thus, the norming study suggests that although the target structures used in this study may not have been the most frequent, they were not entirely infelicitous because participants produced them spontaneously.

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Figure 1.

Depiction of the four experimental conditions. The arrows represent the sequence of movements on the screen. Note that in every condition, a person leaves the University of Illinois, moves to the center rectangle, and then moves to Parkland College. Speakers described the events at point 1 and point 2. Panel A shows the non-repeated character, non-repeated occupation condition. Panel B shows the non-repeated character, repeated occupation condition. Panel C shows the repeated character, non-repeated occupation condition. Panel D shows the repeated character, repeated occupation condition.

Figure 2.

Depicts the sequence of events for the non-repeated character, repeated occupation condition as they appear on the participant's screen. The first utterance is elicited at Panel 2. The second utterance is elicited at Panel 6. The utterance elicited at Panel 6 is the critical utterance.

Figure 3.

a & b Shows the duration pattern in all four conditions across the first time and second time speakers encounter critical words in Experiment 1. The error bars are standard errors.

Figure 4.

a & b Shows the intensity pattern in all four conditions across the first time and second time speakers encounter critical words in Experiment 1. The error bars are standard errors.

Figure 5.

a, b, & c Shows the duration pattern in all four conditions across the first, second, and third time speakers encounter critical words in Experiment 2. The error bars are standard errors.

Figure 6.

a, *b*, & *c* Shows the intensity pattern in all four conditions across the first, second, and third time speakers encounter critical words in Experiment 2. The error bars are standard errors.

Figure 7. Depicts the intensity for repeated characters and non-repeated characters across three encounters over the course of Experiment 2. Data are collapsed across the factor of lexical repetition. The error bars are standard errors.

Table 1

Presents for each condition, the percentage of participants who mentioned the occupation change, the percentage of participants who explicitly disambiguated which character they were describing, and the percentage of participants who used pronouns.

	Mentioned Occupation Change	Disambiguated Characters	Used Pronoun
Non-repeated Character, Non-repeated Occupation	0%	0%	0%
Non-repeated Character, Repeated Occupation	90%	30%	0%
Repeated Character, Non-repeated Occupation	80%	0%	50%
Repeated Character, Repeated Occupation	0%	0%	50%

Table 2
Shows the number and proportion of trials discarded from each condition of Experiment 1

	Non-repeated Occupation	Repeated Occupation
Non-repeated Character	11/128 (8.6%)	2/128 (1.6%)
Repeated Character	8/128 (6.3%)	8/128 (6.3%)

Table 3

Shows the number and proportion of trials discarded from each condition of Experiment 2.

	Non-repeated Occupation	Repeated Occupation
Non-repeated Character	14/312 (4.5%)	5/312 (1.6%)
Repeated Character	8/312 (2.6%)	4/312 (1.3%)