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Early occipital sensitivity to syntactic category is based on form typicality

PSYCHOLOGICAL SCIENCE (IN PRESS)

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ABSTRACT

Syntactic factors can rapidly affect behavioral and neural responses during language processing, however, the mechanisms that allow this rapid extraction of syntactically relevant information remain poorly understood. We address this issue using magnetoencephalography, and find that an unexpected word category (like *The recently princess…*) elicits enhanced activity in visual cortex as early as 120ms, as a function of the compatibility of a word's form with the form properties associated with a predicted word category. Since no sensitivity to linguistic factors has been previously reported for words in isolation at this stage of visual analysis, we propose that predictions about upcoming syntactic categories are translated into form-based estimates, which are made available to sensory cortices. This finding may be a key component to elucidating the mechanisms that allow the extreme rapidity and efficiency of language comprehension.

Introduction

Language processing is one of the most complex cognitive tasks humans routinely engage in. Yet linguistic computation is astonishingly rapid: During spoken or written comprehension, each word is fully analyzed and interpreted in its context within 600ms (see e.g., Friederici, 2002; Marslen-Wilson, 1975; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). One of the fastest processes in this stream of computations appears to be access to a word's syntactic category, i.e., whether it is a noun, verb, adjective and so forth. For example, a word category violation such as the ungrammatical preposition *about* in the sentence fragment *I heard Max's about story* takes only 130ms to affect event-related brain potentials (ERPs; Friederici, Pfeifer, & Hahne, 1993; Neville, Nicol, Barss, Forster, & Garrett, 1991). This is highly surprising given that 100-130ms is essentially the time window of low-level visual or auditory analysis (Di Russo, Martinez, Sereno, Pitzalis, & Hillyard, 2001; Hickok & Poeppel, 2007; Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin, 1999).

To explain this temporal concurrence, we recently proposed a so-called "sensory hypothesis" for early effects of syntactic category violations. On this account, predictions about sentence structure can affect modality-specific brain responses in sensory cortices. The key idea is that in reading, for example, early effects of category violations are dependant on strong visual cues to category, such as affixes (e.g., the *–ed* in reported), and when such category marking elements are unexpected, an occipital mismatch response is elicited during word form analysis. Using magnetoencephalography (MEG), we demonstrated that activity generated in visual cortex at 100-130ms (the visual M100 response) in fact increases when an encountered word mismatches with the expected

syntactic category (Dikker, Rabagliati, & Pylkkänen, 2009). This effect was particularly striking because the M100, which has mainly been studied for words in isolation, had previously only shown sensitivity to variation in stimulus noise and size, and not to linguistic variables (Solomyak & Marantz, 2009; Tarkianen et al., 1999).

In our sensory hypothesis, prediction of upcoming syntactic structure plays a crucial role in explaining the earliness of syntactic category effects. In doing so, our work builds on much previous research showing that in language processing, representations at multiple levels, from phonology to syntax, are predicted and pre-activated. For example, a number of psycholinguistic studies have demonstrated that linguistic anticipation may affect eye movements (e.g., Altmann & Kamide, 1999; Staub & Clifton, 2006) and expectation-based probabilistic models of language comprehension have proven successful in explaining a range of behavioral data (e.g., Hale, 2006; Levy, 2008). Recently, EEG (electroencephalography) and MEG research has also begun to elucidate the neural bases of these prediction effects (e.g., DeLong, Urbach, & Kutas, 2005; Lau, Stroud, Plesch, & Phillips, 2006).

While the notion of structural anticipation helps explain the rapidity of category violation effects in electromagnetic data, a complete theory of this phenomenon needs to characterize the nature of the category cues that the occipital cortex responds to. In the current work, we contrasted two hypotheses about the nature of these cues. One obvious candidate for the relevant type of category cue are affixes and other closed-class morphemes (e.g., *-ness*, *-ly*, *of*, *about*), which are highly frequent and therefore visually salient, as well as strongly indicative of a specific syntactic category. Psycholinguistic research has also shown that closed class morphemes have a special status in language

processing (e.g., Bradley, 1983). Consistent with the hypothesis that the M100 category effect is dependant on the presence of closed class morphemes, in Dikker et al (2009) we only found an M100 effect when the category of the unexpected item was saliently marked by a closed-class morpheme.

Alternatively however, the relevant category cues could be sets of probabilistic form features that are indicative of a particular syntactic category. The crucial prediction would then be that an M100 effect of unexpectedness should be obtained even for words that lack a closed-class morpheme, as long as their form is overall characteristic of the word's syntactic category. Our previous M100 findings on closed-class morphemes could easily be explained by this hypothesis, since a word with a category-marking morpheme is very likely to look typical of its category.

This form-typicality hypothesis derives from research demonstrating that systematic, probabilistic, form-based regularities exist among the words of a given syntactic category, and these regularities have consequences for on-line syntactic processing (Arciuli & Monaghan, 2009; Farmer, Christiansen, & Monaghan, 2006; Kelly, 1992; Monaghan, Christiansen, & Chater, 2007). In one recent study, Farmer et al. (2006) demonstrated via a corpus analysis that English nouns and verbs form clusters in phonological space, reflecting the relative occurrence of certain features in either category. While most nouns and verbs are 'typicality neutral', containing form features that are equally common in both categories, there are also clearly typical nouns and verbs (more 'typical' nouns share less features with verbs and vice versa). Farmer et al. (2006) found that English speakers were faster to read typical words. Staub, Grant, Clifton, & Rayner (2009) failed to replicate these effects, but due to a large deviation from the

original Farmer et al. studies, expectations for either a noun or a verb were potentially weakened. The fact that this difference in design attenuated the effect of typicality demonstrates the potential importance of prediction.

Tanenhaus and Hare (2007) argue that Farmer et al's findings might help explain eye movement patterns during reading: effects on first fixations could be contingent upon form feature predictions. This would be consistent with an early visual M100 effect for words containing unexpected form features. Crucially then, the visual M100 component should be sensitive to the probabilistic distribution of form features across the entire mental lexicon, in contrast to being specifically tuned to detecting a small set of closed-class morphemes.

Previous electrophysiological research on lexico-semantic anticipation has already demonstrated that form predictions are not restricted to closed-class morphology. For example, Laszlo & Federmeier (in press) show that overall orthographic similarity to a predicted word affects the amplitude of the N400 component, an ERP response sensitive to lexico-semantic expectancy (e.g., Kutas, Van Petten, & Kluender, 2006). Similar experiments in the auditory domain have shown that words which violate phonological, but not semantic, predictions generate an ERP effect that can be dissociated from the N400 response (the Phonological Mismatch Negativity, see e.g., Connolly & Phillips, 1994). However, both the N400 and the Phonological Mismatch Negativity clearly reflect later stages of processing than the MEG M100 response. Further, these studies investigated predictions for individual words, rather than expectations for syntactic categories.

To test whether, in the context of syntactic prediction, closed-class morphemes have a special status as category indicators, or whether form typicality can also serve as a category cue for the visual cortex, we examined the visual M100 effect for three types of nouns presented in expected or unexpected contexts in word-by-word reading: (i) bimorphemic nouns (with a closed-class category marking morpheme like *farm-er, princ-ess, art-ist*); (ii) monomorphemic 'typical' nouns containing form properties that are indicative of the noun category (e.g., *movie, soda*), and (iii) neutral nouns (no clear form bias toward either nouns or verbs). Bimorphemic nouns and typical nouns were about equally indicative of the noun category. To manipulate syntactic context, the critical noun was preceded by either an adjective (*the beautiful…*), where a noun is highly expected, or by an adverb (*the beautifully…*), rendering nouns unexpected and instead inducing a strong expectation for a participle (like *dressed*).

If word category violations are detected during early visual processing exclusively on the basis of closed-class morphemes in the input, then only bimorphemic nouns should show an M100 effect of expectedness. Alternatively, if form typicality is sufficient, then an M100 effect should be present for typical nouns as well. Under neither hypothesis should neutral nouns elicit an M100 expectedness effect.

In addition to comparing the averaged M100 responses to each noun type by sentence context, we analyzed dipole waveforms for single-trial data. This allowed us to conduct a multiple-regression analysis addressing whether the presence of a closed-class morpheme leads to an M100 effect independently of a word's form typicality.

2 Methods

Supplementary information is available on-line presenting further details regarding the methods and materials.

2.1 Participants

15 healthy right-handed subjects participated (6 female, average age: 23). All had normal or corrected-to-normal vision and gave informed consent.

2.2 Materials

40 bimorphemic, typical monomorphemic, and neutral monomorphemic nouns were presented to participants in both expected and unexpected contexts (e.g., *The beautiful princess was painted* vs. *The beautifully princess was painted*). Sentences were presented word-by-word (300ms on/off). Nouns were drawn from Farmer et al.'s (2006) analysis of the CELEX corpus. Farmer et al. (2006) calculated the phonological distance between two words based on the number of overlapping and non-overlapping phonetic features. Typicality scores for each word were then obtained by subtracting its distance to all verbs from its distance to all nouns. Typicality scores for the nouns and verbs in CELEX ranged from -.632 to +.498, with more negative scores denoting a more noun-like form, scores around 0 denoting neutrality, and more positive numbers denoting forms more typical of verbs. The typical noun condition had a mean score of -.42 (SD=.08), while the neutral nouns had forms that were approximately equally similar to both categories (M =.00, SD=.02). Bimorphemic nouns were also typical of the category (M =-.34, SD=.15), but less so than the typical nouns. Targets were matched for frequency and are listed in

Appendix A (available online). Deriving suitable typicality values for our items unfortunately resulted in length differences between all conditions (neutral nouns were shortest, bimorphemic nouns longest). However this did not appear to affect our results (see multiple regression analysis below). To avoid habituation, we used 240 matched filler sentences in which adjectives and adverbs were followed by participles (e.g., *the beautiful/beautifully dressed*…). All sentences are listed in Appendix B.

2.3 Procedure

Participants read the stimuli on a screen approximately 17 inches from their head, while sat in a dimly lit, magnetically sealed chamber, and judged each sentence's grammaticality after the final word. The entire recording session lasted approximately 40 minutes. Data were collected using a whole-head 275-channel gradiometer (CTF, Vancouver Canada) system sampling at a 600Hz in a band between 0.1 and 200Hz.

2.4 Data Analysis

Data was high/low pass filtered (at 1/40Hz) and automatically cleaned of artifacts (approximately 10% of trials rejected). To estimate the generating source of the M100 we used a multiple-source model (BESA Software; Brain Electrical Source Analysis 5.1) taking data from all sensors. Dipole locations did not differ over conditions, nor did the number of additional dipoles used in the model.

To test for M100 effects in the averaged data we performed a 2 (Expectation level: Expected vs. Unexpected) by 3 (Noun Type: Bimorphemic vs. Typical vs. Neutral) within-subjects ANOVA on the mean amplitude of a 15ms interval centered around the

average M100 peak for each condition and subject, as in Dikker et al. (2009). Post-hoc t-tests were used to examine effects within each noun type.

To test for independent contributions of closed-class morphology and typicality to the M100 effect we used an individual trial mixed-effects regression analysis. We estimated peak M100 amplitude for each trial, using the previously generated source model, and then regressed amplitude against predictors for the effects of morphology and typicality, and other psycho-linguistically relevant variables (listed in Table 1, and described and motivated in more detail in the supplementary materials). To characterize how form typicality mismatches with prediction, we estimated how far (in normalized units of typicality) the typicality of each encountered word lay from the mean typicality score of the expected word category. This regression term, predicted typicality mismatch, should be reliably greater than 0 if the difference between expected and encountered typicality affects the M100. To test if closed-class morphology has a reliable independent effect, we included a morphology-presence by context interaction term.

3 Results

2.1 Results for averaged data: Expectedness and M100 amplitude

Figure 1 shows the average M100 dipole activity per condition. A 2 (Expectedness: Expected (noun expected) vs. Unexpected (participle expected)) by 3 (Noun Type: Bimorphemic vs. Typical vs. Neutral) within-subjects ANOVA on M100 amplitude revealed a main effect of Expectedness ($F(1,14)=4.708$, $p=.048$, $\eta^2_{=}.252$), and an interaction between Expectedness and Noun Type ($F(2,28)=3.614$, $p=.017$, $\eta^2_{=}.467$)

indicating that this effect was not present in each condition. There was no main effect of Noun Type ($F(1,14)=1.113$, $p=.299$, $\eta^2_{=}.169$).

Pair-wise comparisons confirmed that the M100 amplitude difference between expected and unexpected nouns was reliable for the bimorphemic nouns ($t(14)=4.18$, $p<.001$, $\eta^2_{=}.56$), but also for typical nouns ($t(14)=2.15$, $p=.049$, $\eta^2_{=}.25$). Neutral nouns showed no effect ($t(14)=.32$, $p=.75$, $\eta^2_{=}.01$).

Because the M100 peak's latency varied across subjects, we repeated the analysis using each individual's by-condition peak amplitude as our dependent measure. This produced essentially identical results, with reliable differences between expected and unexpected bimorphemic nouns ($t(14)=3.634$, $p=.003$, , $\eta^2_{=}.49$) and typical nouns ($t(14)=3.171$, $p=.007$, $\eta^2_{=}.42$), but not neutral nouns ($t(14)=.733$, $p=.47$, $\eta^2_{=}.04$).

INSERT FIGURE 1 HERE

3.2 Single Trial Analysis

The results of the regression are presented in Table 1. Despite the model's high deviance score, indicating a low overall fit because of the noisy individual trial data, the results are clearly interpretable. Controlling for all other variables, predicted typicality mismatch had a reliable effect on M100 amplitude: words whose form was less consistent with the predicted word category generated a reliably larger M100, consistent with the results in the by-condition analysis (ß=3.77, SE=1.52, $t=2.49$, $p_{MCMC}=.016$).

However, the regression failed to provide any evidence for a special role for closed-class morphemes in generating an M100 effect. The increased M100 amplitude for

unexpected nouns containing a closed-class morpheme was no greater than would be expected given their predicted typicality mismatch alone, as indicated by the small and non-significant interaction between the variables coding for context and morpheme presence.

INSERT TABLE 1 HERE

One other reliable effect emerged from the regression: nouns encountered in an unexpected context produced a reliably larger M100 (ß=2.84, SE=1.36, t=2.09, p_{MCMC}=.04). There was no effect of orthographic length, suggesting that the small length differences between conditions did not affect any of our results.

Discussion

The research presented here sought to elucidate the remarkably rapid onset of syntactic category effects in language processing. Both in a factorial design and using a multiple regression on individual trials, the MEG visual M100 response was sensitive to form typicality, and not just to a small set of closed-class morphemes. This strongly suggests that the brain uses prior syntactic context to predict not only a word's syntactic category (e.g., Hale, 2006; Lau et al., 2006; Levy, 2008), but also form features that are probabilistically associated with the predicted category.

A central aspect of any explanation of these occipital word category effects is whether the effect arises in an entirely top-down fashion, or alternatively, whether the regions generating the visual M100 house some type of category representations. Our

results cannot strictly settle this issue, as it is impossible to discern whether the M100 effect results from low-level form feature matching, or rather from a true word category mismatch.

However, in the context of our extant understanding of the visual M100 as a low-level response, it would be very surprising if the M100 generator was implicated in the processing of word category. For example, although some evidence from EEG suggests that orthographic regularity affects early visual processing (Hauk et al., 2006), Tarkiainen et al. (1999) did not report any differential activity at the M100 response to letter strings compared to symbols. Similarly, in a recent MEG study using a lexical decision task, no effects of lexical factors were found before 150ms (Solomyak & Marantz, 2009). We therefore believe that our results are more plausibly explained in terms of a mismatch occurring at the form feature level, and that the M100 generator is in fact insensitive to higher-level linguistic properties like word category.

At this point the detailed nature of the form representations available to the M100 generator remains somewhat open. For example, localization of the M100 response (Itier et al., 2006) points to posterior occipital areas that have been shown indifferent to the distinction between letters and non-letters suggesting a level of processing at the sub-letter level, but also to slightly more anterior visual regions that have been implicated in letter level processing (see Dehaene et al., 2007 for a discussion of the functional organization of different levels of written word processing across occipito-temporal cortex).

Our results relate to the more general hypothesis that contextual predictions might affect processing in sensory cortices for a number of cognitive domains (Bar, 2007).

However, evidence pertaining to this has been limited. Summerfield et al., (2006) for example, find evidence for contextual prediction in object identification, but context was defined very globally, in terms of task demands that varied between experimental blocks. In natural language processing, by contrast, context is dynamic and local. Word category predictions are updated continuously, and are not subject to conscious selective attention. As such, our findings may provide one of the first demonstrations of the role of visual cortex in contextual prediction under relatively naturalistic conditions.

Conclusion

This research provides new evidence for the mechanisms by which prediction allows rapid language processing, showing that probabilistic form-estimates based on word category predictions affect the earliest stages of visual analysis. Future work will need to address exactly how the occipital expectancy effects modulate subsequent processing, but the present findings offer one important step toward elucidating the cognitive and neural mechanisms underlying the ease and rapidity of language processing.

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FIGURE 1 - Grandaveraged waveforms for the M100 dipole sources

Grandaveraged waveforms for the M100 dipole sources per comparison (blue = expected / red = unexpected). n=15. 15ms intervals centered around the average M100 peak are indicated by the red and blue dotted lines. Mean dipole locations and orientations (blue = expected / red = unexpected) as well as the dipoles from the individual participants (grey) are plotted per noun type. Results reveal effects of expectedness on M100 amplitude for the typical nouns and for the bimorphemic nouns, but not for the neutral nouns (= p <.05).*

TABLE 1 – Results of the linear regression analysis of single trial M100 amplitude

Predictors entered into the regression against peak M100 amplitude (Deviance = 29354, Number of observations = 3136), with their estimated coefficients, the standard error of that coefficient, the associated t statistic for the coefficient and a p value simulated using Markov-Chain Monte Carlo methods. These results reveal a reliable effect of predicted typicality mismatch on M100 amplitude: the further a word's typicality lies from its expected typicality, the greater the M100 amplitude. However, the presence of a morpheme did not interact with context: there was no specific effect of context for bimorphemic items that was not predicted by their predicted typicality mismatch.

FIGURE 1

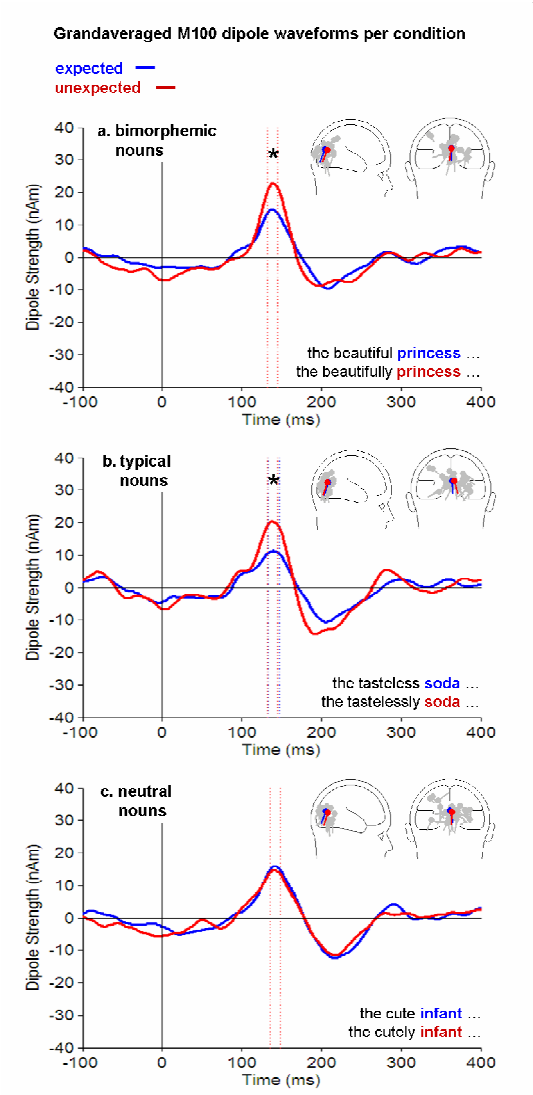
Grandaveraged M100 dipole waveforms per condition
expected
unexpected
a. bimorphemic nouns
b. typical nouns
c. neutral nouns
Dipole Strength (nAm)
Time (ms)
the beautiful princess …
the beautifully princess …
the tasteless soda …
the tastelessly soda …
the cute infant …
the cutely infant …

TABLE 1

	ß	Std.Error	*t* statistic	p_{MCMC}
Intercept	27.23	5.86	4.65	<0.01
Context	2.84	1.36	2.09	0.040
Morpheme Presence	-1.96	1.57	1.25	0.21
Predicted Typicality Mismatch (M = 1.61, SD = 1.07)	3.77	1.52	2.49	0.016
Orthographic Length (M = 5.66, SD = 1.46)	0.29	0.63	0.46	0.64
log Frequency (M = 5.85, SD = 1)	0.25	0.47	0.53	0.60
No. of Syllables	0.62	2.37	0.26	0.79
Orthographic Neighborhood Density (M = 3.63 SD = 4.72)	0.04	0.15	0.29	0.77
Phonological Length (M = 5.48, SD = 1.36)	0.18	0.75	0.24	0.81
Morpheme Presence * Context Interaction	0.46	1.98	0.23	0.82

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Supplementary File: Detailed Methods

2 Methods

2.1 Participants

15 healthy right-handed subjects participated (6 female, average age: 23). All had normal or corrected-to-normal vision and gave informed consent. All were students or employees at New York University.

2.2 Materials

Three classes of nouns were presented in both expected and unexpected syntactic environments (40 items per condition; see Table 1 for example sentences): (i) bimorphemic nouns (with a closed-class category marking suffix like *-er / -ess*); (ii) typical nouns (containing form properties that are indicative of the noun category), and (iii) neutral nouns (no clear form bias toward either nouns or verbs).

The target nouns and their typicality scores were drawn from Farmer et al.'s (2006) analysis of the phonological features of the nouns and verbs in CELEX, summarized in the main paper and detailed in Farmer et al. (2006). Farmer et al. (2006) calculated the phonological distance between two words based on the number of overlapping and non-overlapping phonetic features. Typicality scores for each word were then obtained by subtracting its distance to all verbs from its distance to all nouns. More typical nouns were phonologically closer to the distribution of nouns than verbs, and so had a negative score (mean typicality = -.42, SD = .08), while more neutral nouns were

approximately equally similar to both categories, and so had a score around 0 (mean typicality = .00, SD = .02). Bimorphemic nouns were also typical of the category (mean typicality = -.34, SD = .15), but less so than the typical nouns. Words were matched for frequency. All noun targets are listed in Appendix A below.

Participants read 240 target sentences. To manipulate syntactic predictability, the target nouns were preceded by a modifying adjective (*the cute princess…*) or adverb (*the cutely princess…*), as in Table 1. In offline judgments, people overwhelmingly predict that the next word will be a noun given the former context, and a participle following the latter (see Dikker et al., 2009). To avoid habituation to the unexpected stimuli, we used 240 matched filler sentences in which adjectives and adverbs were followed by participles (e.g., *the cute/cutely dressed…*).

SUPPLEMENTARY TABLE 1 - Examples of experimental stimuli

240 target sentences (40 per condition) were intermixed with 240 filler sentences (also 40 per cell).

Word category		expected	unexpected
bimorphemic nouns	target	The beautiful **princess** was painted.	The beautifully **princess** was painted.
	filler	The beautifully painted princess smiled.	The beautiful painted princess smiled.
typical nouns	target	The tasteless **soda** was marketed.	The tastelessly **soda** was marketed.
	filler	The tastelessly marketed soda sold well.	The tasteless marketed soda sold well.
neutral nouns	target	The cute **infant** was dressed.	The cutely **infant** was dressed.
	filler	The cutely dressed infant laughed.	The cute dressed infant laughed.

2.3 Procedure

Participants read the stimuli on a screen approximately 17 inches from their head, while sitting in a dimly lit, magnetically sealed chamber. Each trial began with a fixation point in the center of the screen, and participants initiated the sentence by pressing a button. The sentences were presented word by word (300ms on, 300ms off), in non-proportional Courier font (font size = 90). The end of each sentence was indicated with a question mark, at which participants judged whether the sentence was well-formed with a button press using their left hand. The entire recording session lasted approximately 40 minutes.

Data were collected using a whole-head 275-channel gradiometer (CTF, Vancouver Canada) system sampling at a 600Hz in a band between 0.1 and 200Hz.

2.4 Data Analysis

We used two methods of analysis. First, we analyzed the averaged data of our 2 (Expectedness: Expected vs. Unexpected) by 3 (Noun Type: Neutral vs. Typical vs. Bimorphemic) factorial design in order to test if an M100 effect was only obtained for the bimorphemic words or whether highly typical nouns would also elicit it. Second, we employed a multiple-regression analysis on individual trial data to assess the relative contributions of form typicality and morphological structure to M100 amplitude.

Pre-processing

Prior to analysis, the MEG data were cleaned of artifacts. On average, this resulted in the exclusion of less than 10 % of the data per subject. Recordings were high and low-pass filtered at 1 and 40 Hz respectively. For the by-condition analysis, data were averaged for

each condition over a 900ms epoch with a 300ms pre-stimulus interval, time-locked to the appearance of the target word.

Dipole Modeling of the M100 Response

The visual M100 response typically shows a single posterior right-lateralized outgoing field and a left-lateralized posterior re-entering field at around 100-150ms (e.g., Dikker et al., 2009; Itier et al., 2006; Pylkkänen et al., 2006; Tarkianen et al., 1999). The response is generated bilaterally in occipital cortex, close to midline, arguably with maximum intensity in the cuneus, lingual gyrus, and BA 17 (Itier et al., 2006).

As in Dikker et al. (2009), we used a multiple-source model (BESA Software; Brain Electrical Source Analysis 5.1) taking data from all sensors, to estimate the discrete locations of the M100 current generator. Activity was modeled using data from each averaged condition. These models were used for both the by-condition and single trial analysis. Only models that were consistent with both the magnetic field maps and the minimum norm estimates were accepted for analysis.

Dipole solutions of all 15 subjects contained a typical posterior M100 dipole in all conditions (average location [Cartesian coordinate system referenced to the fiducials]: x = 0.04, y = -0.61, z = 0.2; orientation: x = 0.05, y = -0.26, z = -0.68), with an average peak latency of 134ms (SD = 16) and an average peak amplitude of 23.5nAm (SD = 6) across subjects. 2 (Expectedness: Expected vs. Unexpected) by 3 (Noun Type: Neutral vs. Typical vs. Bimorphemic) within-subjects ANOVA's for the *x*, *y* and *z* locations and orientations of the M100 dipoles revealed no significant main effects or interactions. For most subjects, accurate modeling of the M100 source also required some additional

concurrent dipoles (M = 1.7, SD = .4 [total nr. of dipoles per model]), but there was no consistent pattern in the location or direction of the additional dipoles, nor reliable differences between conditions with respect to the number of additional dipoles or goodness-of-fit of the multi-dipole model, which averaged 88.8% (SD = 4) at the M100 peak.

Analysis of averaged responses

To test for effects of expectation at the M100, as well as for differences between the different noun types, we performed a 2 (Expectation level: Expected vs. Unexpected) by 3 (Noun Type: Bimorphemic vs. Typical vs. Neutral) within-subjects ANOVA on the mean amplitude of a 15ms interval centered around the average M100 peak for each condition and subject, as in Dikker et al. (2009). Post-hoc t-tests were used to examine effects within each noun type.

Analysis of single trial data

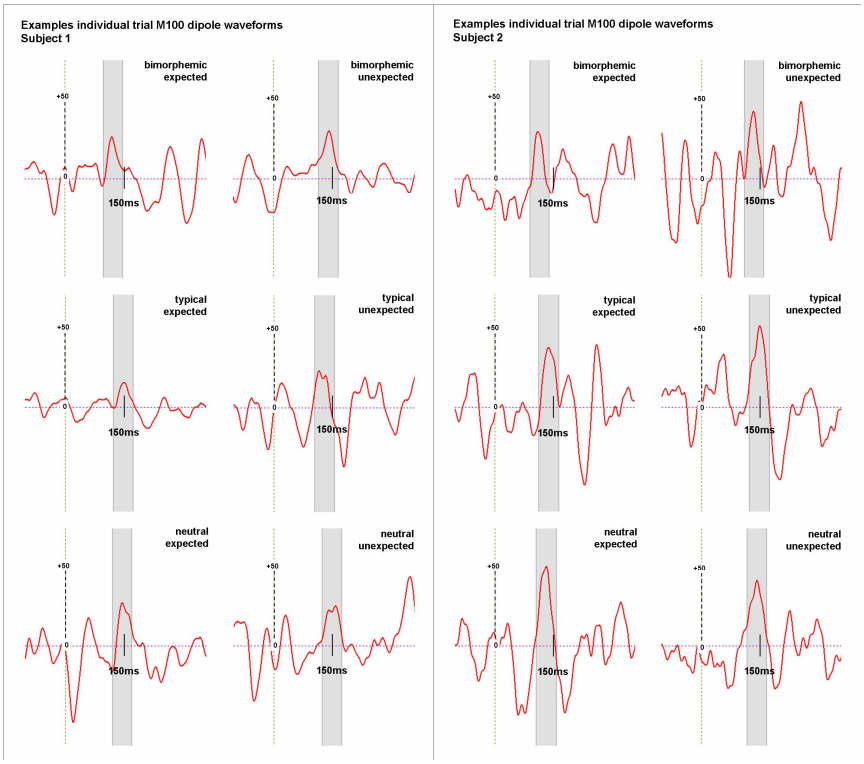
To investigate whether the presence of a closed-class morpheme on a word contributed to an expectation-driven change in the M100 response independently of form typicality, we employed a multiple-regression analysis on individual trial data.

Because the signal-to-noise ratio is generally too low for dipole modeling on individual trial data, we used the dipole models that had been fit on the averaged data as a spatial filter, and exported the waveforms of their M100 dipoles for each trial. To estimate peak M100 amplitude, we extracted the point in each trial with the highest amplitude in a 50ms window centered on the peak latency of the M100 for that particular condition and subject in the by-condition analysis. Trials whose M100 amplitude

diverged more than 2.5 SD from the subject's overall peak amplitude were excluded, as were behaviorally incorrect trials (Mean number of trials per subject = 209, SD = 21.5). Figure 1 shows examples of the M100 dipole waveform for individual trials from each condition for two (out of 15) subjects.

SUPPLEMENTARY FIGURE 1 - Examples of M100 waveforms on individual trials

Examples of M100 dipole waveforms on individual trials from each condition, displayed for -100 to + 350 ms of the presentation of the target noun. A 50 ms time-window centered around the M100 peak amplitude per condition/subject is highlighted in grey for each sample trial (see text), and the 150ms post-stimulus onset point is marked on the x-axis. These examples show clear peaks in the M100 window for all conditions.



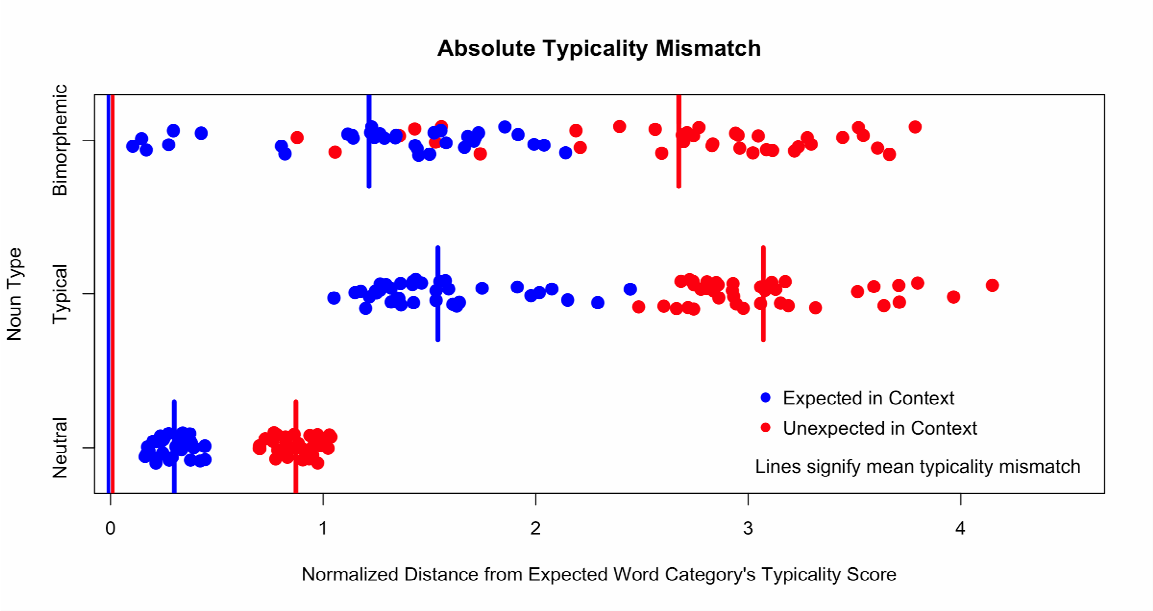
We then used a mixed-effects linear regression to predict peak M100 amplitude. To test for an effect of expectation exclusive to words containing a closed-class morpheme, our regression included an interaction between a dummy variable coding if the noun contained a closed-class morpheme and a dummy coding if it was expected or unexpected in its context (both dummies were also included as separate variables). If closed-class morphemes lead to an additional effect of expectation this interaction should be reliable.

Next we constructed a regressor to measure the mismatch between the average typicality score of the predicted word category, and the typicality score of the encountered word. If typicality does drive the M100 effect, nouns that strongly mismatch typicality predictions will result in a larger M100 response. To quantify how encountered words matched predictions, we calculated the absolute normalized distance between the typicality score of each encountered noun and the mean typicality score of the predicted word category (either a noun or a participle, depending on the preceding context). We estimated the typicality distributions of the predicted word categories using the typicality scores in the corpus from which our experimental items were drawn (for further details see the Materials Section, and Farmer et al., 2006). The distributions of the two word categories were, nouns: $\underline{M}$ = -0.07, SD = 0.23, N = 2144; Participles: $\underline{M}$ = 0.17, SD = 0.19, N = 494. The mean of the normalized predicted typicality mismatch was 1.61 standard deviations (SD = 1.07). As reflected in Figure 2, neutral nouns closely matched both nouns' (expected context) and participles' (unexpected context) average typicality score (indicated by zero-point on the left). Bimorphemic and typical nouns provided a worse match on average, in addition to showing larger differences in match between the

expected and unexpected conditions, with unexpected nouns producing a larger mismatch. In addition, they showed more variance than the neutral nouns, especially the bimorphemic nouns.

SUPPLEMENTARY FIGURE 2 - Absolute typicality mismatch for each noun type

Absolute typicality mismatch (0 on left = perfect match) for each item clustered by noun type (y-axis) and expected (blue; noun predicted) vs. unexpected (red; participle predicted) within each noun category. As can be seen, neutral nouns closely matched the predicted typicality scores, with little difference between expected and unexpected contexts. Bimorphemic and typical nouns provided a worse match on average, in addition to showing larger differences between the expected and unexpected conditions. In addition, they showed more variance than the neutral nouns, especially the bimorphemic nouns.



We also added a number of additional predictors in order to control for factors that have previously been shown to affect both behavioral and neural correlates of word recognition (scores were calculated using the English Lexicon Project, Balota et al., 2007). Each word was coded for:

(1) Orthographic length, the number of letters in a word (M = 5.66, SD = 1.46). The amplitude of the visual M100 response to a word typically increases as the number of letters in a word increases (Tarkiainen, Helenius, Hansen, Cornelissen & Salmelin, 1999). Exactly how length affects visual word processing, however, is unclear (see New, Ferrand, Pallier & Brysbaert, 2006 for review).

(2) Log frequency (M = 5.85, SD = 1). As the frequency with which a word occurs increases, the reaction time to identify that word decreases (see Balota, Yap & Cortese, 2006 for review). Lexical frequency typically does not affect MEG or EEG components until after 100ms; some reports suggest the earliest effects are seen between 140 and 170ms (Sereno, Rayner & Posner, 1998; Haul & Pulvermüller, 2004; Assadolahi & Pulvermüller, 2003). However one recent EEG study, using a correlational analysis, finds an effect of frequency at 110ms (provisionally located in a posterior portion of left temporal lobe), with low frequency words producing a larger signal on the EEG (Hauk, Davis, Ford, Pulvermüller & Marslen-Wilson, 2006).

(3) Number of syllables (M = 1.79, SD = 0.41). Whether the number of syllables in a word plays a role in visual word recognition is controversial (see Balota, Yap & Cortese, 2006, for review)

(4) Orthographic neighborhood density, measured using Coltheart's N (M = 3.63 SD = 4.72), is the number of words of the same length that mismatch a target word by only one letter. Neighborhood density typically predicts recognition time, although the strength and direction of that prediction is controversial. One recent ERP study found an effect of Coltheart's N at 100ms (Hauk, Pulvermüller., Ford, Marslen-Wilson & Davis, 2009); other studies find a later onset (Holcomb, Grainger & O'Rourke, 2002).

(5) Phonological length, the number of phonemes in a word (M = 5.48, SD = 1.36)**.** Numerous studies indicate that phonological information is accessed even during the early stages of written word recognition (for review see Frost, 1998) and phonological impairments underlie common reading disorders (e.g., Snowling, 2000). ERP evidence typically suggests that phonological information is accessed sometime between 200-500ms, although there is also evidence for earlier effects (e.g., Ashby, Sanders & Kingston, 2009).

Finally, we included random intercepts for both subjects and items. To fit our regression model we used the *lmer* function from the *lme4* library (Bates, Maechler & Dai, 2008) of the software package R, which estimates its parameters using restricted maximum likelihood. The reliability of each term was calculated from 10000 Markov-chain Monte Carlo simulations, using the *pvals.fnc* function of the *languageR* package (Baayen, 2008) in *R*.

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Appendix A. Noun targets for each noun type

bimorphemic	typical	neutral
action	bible	ash
artist	bonus	asset
baker	bowel	bush
banker	camel	calf
boredom	cargo	champagne
bowler	cellar	clay
boxer	charcoal	cliff
brightness	china	costume
dancer	choir	cue
darkness	circus	death
driver	colonel	device
failure	cypress	disease
fairness	diesel	forest
fighter	dollar	goal
freedom	drama	hall
hostess	eagle	limb
illness	era	loss
lawyer	furnace	lung
leader	garlic	mall
likeness	hour	meal
lover	jargon	mile
madness	lion	mom
movement	mackerel	moss
owner	mama	nun
pavement	marble	pill
payment	margin	plea
player	money	regime
poster	motel	rhythm
reader	nylon	robin
sadness	palace	rug
speaker	parcel	skull
teacher	pillar	sum
tourist	pupil	symptom
treatment	soda	system
waiter	sofa	technique
walker	target	terrain
weakness	title	tray
winner	trial	volume
worker	vehicle	week
writer	villa	witch

Appendix B. Stimuli

Bimorphemic Nouns

Expected

1. The brilliant artist was promoted.
2. The successful baker was robbed.
3. The smart banker was ruined.
4. The intense boredom was detested.
5. The proud bowler was welcomed.
6. The aggressive boxer was attacked.
7. The proper brightness was adjusted.
8. The beautiful hostess was dressed.
9. The deep darkness was feared.
10. The clever tourist was tricked.
11. The anonymous driver was identified.
12. The absurd failure was overlooked.
13. The systematic fairness was violated.
14. The individual freedom was protected.
15. The heroic fighter was defeated.
16. The swift action was executed.
17. The strange illness was cured.
18. The skillful lawyer was cornered.
19. The new leader was appointed.
20. The brilliant likeness was reviewed.
21. The passionate lover was murdered.
22. The public madness was denounced.
23. The massive movement was ignored.
24. The recent owner was deceased.
25. The excellent player was trained.
26. The violent poster was removed.
27. The poor reader was instructed.
28. The bad pavement was replaced.
29. The suspicious payment was investigated.
30. The earnest sadness was discussed.
31. The incredible dancer was talented.
32. The eloquent speaker was humiliated.
33. The hygienic treatment was prepared.
34. The loud teacher was mocked.
35. The polite waiter was addressed.
36. The quick walker was injured.
37. The painful weakness was exposed.
38. The excited winner was celebrated.
39. The careful worker was watched.
40. The comical writer was ridiculed.

Unexpected

1. The brilliantly artist was promoted.
2. The successfully baker was robbed.

3. The smartly banker was ruined.
4. The intensely boredom was detested.
5. The proudly bowler was welcomed.
6. The aggressively boxer was attacked.
7. The properly brightness was adjusted.
8. The beautifully hostess was dressed.
9. The deeply darkness was feared.
10. The cleverly tourist was tricked.
11. The anonymously driver was identified.
12. The absurdly failure was overlooked.
13. The systematically fairness was violated.
14. The individually freedom was protected.
15. The heroically fighter was defeated.
16. The swiftly action was executed.
17. The strangely illness was cured.
18. The skillfully lawyer was cornered.
19. The newly leader was appointed.
20. The brilliantly likeness was reviewed.
21. The passionately lover was murdered.
22. The publicly madness was denounced.
23. The massively movement was ignored.
24. The recently owner was deceased.
25. The excellently player was trained.
26. The violently poster was removed.
27. The poorly reader was instructed.
28. The badly pavement was replaced.
29. The suspiciously payment was investigated.
30. The earnestly sadness was discussed.
31. The incredibly dancer was talented.
32. The eloquently speaker was humiliated.
33. The hygienically treatment was prepared.
34. The loudly teacher was mocked.
35. The politely waiter was addressed.
36. The quickly walker was injured.
37. The painfully weakness was exposed.
38. The excitedly winner was celebrated.
39. The carefully worker was watched.
40. The comically writer was ridiculed.

Typical Nouns

Expected

1. The timid eagle was stroked.
2. The accurate bible was translated.
3. The large bonus was unclaimed.
4. The unhealthy bowel was treated.
5. The lazy camel was disciplined.
6. The secret cargo was packed.
7. The dim cellar was illuminated.
8. The fresh charcoal was added.

9. The elaborate china was crafted.
10. The excellent choir was directed.
11. The popular circus was acclaimed.
12. The historic colonel was celebrated.
13. The loud music was played.
14. The new diesel was purchased.
15. The cheap dollar was traded.
16. The horrible drama was handled.
17. The sad era was recalled.
18. The vast furnace was expanded.
19. The strong garlic was preferred.
20. The initial hour was supervised.
21. The scientific jargon was tested.
22. The brutal lion was killed.
23. The common mackerel was consumed.
24. The heavy mama was loved.
25. The beautiful marble was polished.
26. The narrow margin was eroded.
27. The new money was introduced.
28. The bad motel was insulated.
29. The tight nylon was tied.
30. The royal palace was decorated.
31. The wrong parcel was delivered.
32. The firm pillar was erected.
33. The careless pupil was treated.
34. The tasteless soda was marketed.
35. The strange sofa was replaced.
36. The easy target was missed.
37. The honorable title was revoked.
38. The grueling trial was debated.
39. The new vehicle was acquired.
40. The extravagant villa was adorned.

Unexpected

1. The timidly eagle was stroked.
2. The accurately bible was translated.
3. The largely bonus was unclaimed.
4. The unhealthily bowel was treated.
5. The lazily camel was disciplined.
6. The secretly cargo was packed.
7. The dimly cellar was illuminated.
8. The freshly charcoal was added.
9. The elaborately china was crafted.
10. The excellently choir was directed.
11. The popularly circus was acclaimed.
12. The historically colonel was celebrated.
13. The loudly music was played.
14. The newly diesel was purchased.
15. The cheaply dollar was traded.

16. The horribly drama was handled.
17. The sadly era was recalled.
18. The vastly furnace was expanded.
19. The strongly garlic was preferred.
20. The initially hour was supervised.
21. The scientifically jargon was tested.
22. The brutally lion was killed.
23. The commonly mackerel was consumed.
24. The heavily mama was loved.
25. The beautifully marble was polished.
26. The narrowly margin was eroded.
27. The newly money was introduced.
28. The badly motel was insulated.
29. The tightly nylon was tied.
30. The royally palace was decorated.
31. The wrongly parcel was delivered.
32. The firmly pillar was erected.
33. The carelessly pupil was treated.
34. The tastelessly soda was marketed.
35. The strangely sofa was replaced.
36. The easily target was missed.
37. The honorably title was revoked.
38. The gruelingly trial was debated.
39. The newly vehicle was acquired.
40. The extravagantly villa was adorned.

Neutral Nouns

Expected

1. The fine ash was dispersed.
2. The terrific asset was exploited.
3. The sparse bush was planted.
4. The tender calf was nursed.
5. The cheap champagne was stored.
6. The colorful clay was painted.
7. The impressive cliff was climbed.
8. The incorrect costume was assigned.
9. The terrible death was unexpected.
10. The fashionable device was designed.
11. The aggressive disease was cured.
12. The calm forest was explored.
13. The noble goal was reached.
14. The magnificent hall was decorated.
15. The awkward cue was observed.
16. The painful limb was amputated.
17. The terrible loss was announced.
18. The bad lung was damaged.
19. The spacious mall was constructed.
20. The nice meal was served.
21. The final mile was crossed.

22. The heroic mom was rescued.
23. The soft moss was eliminated.
24. The harsh nun was dismissed.
25. The organic pill was fabricated.
26. The desperate plea was delivered.
27. The dishonest regime was deceived.
28. The ingenious rhythm was composed.
29. The cheerful robin was welcomed.
30. The cheap rug was knotted.
31. The firm skull was smashed.
32. The fair sum was distributed.
33. The wrong symptom was diagnosed.
34. The excellent system was marketed.
35. The proper technique was executed.
36. The hazardous terrain was fenced.
37. The neat tray was stored.
38. The correct volume was adjusted.
39. The hectic week was planned.
40. The cruel witch was punished.

Unexpected

1. The finely ash was dispersed.
2. The terrifically asset was exploited.
3. The sparsely bush was planted.
4. The tenderly calf was nursed.
5. The cheaply champagne was stored.
6. The colorfully clay was painted.
7. The impressively cliff was climbed.
8. The incorrectly costume was assigned.
9. The terribly death was unexpected.
10. The fashionably device was designed.
11. The aggressively disease was cured.
12. The calmly forest was explored.
13. The nobly goal was reached.
14. The magnificently hall was decorated.
15. The awkwardly cue was observed.
16. The painfully limb was amputated.
17. The terribly loss was announced.
18. The badly lung was damaged.
19. The spaciously mall was constructed.
20. The nicely meal was served.
21. The finally mile was crossed.
22. The heroically mom was rescued.
23. The softly moss was eliminated.
24. The harshly nun was dismissed.
25. The organically pill was fabricated.
26. The desperately plea was delivered.
27. The dishonestly regime was deceived.
28. The ingeniously rhythm was composed.

29. The cheerfully robin was welcomed.
30. The cheaply rug was knotted.
31. The firmly skull was smashed.
32. The fairly sum was distributed.
33. The wrongly symptom was diagnosed.
34. The excellently system was marketed.
35. The properly technique was executed.
36. The hazardously terrain was fenced.
37. The neatly tray was stored.
38. The correctly volume was adjusted.
39. The hectically week was planned.
40. The cruelly witch was punished.

Participles

Expected

1. The brilliantly promoted artist created a masterpiece.
2. The successfully robbed baker cried.
3. The smartly ruined banker needed a job.
4. The intensely detested boredom lingered on.
5. The proudly welcomed bowler entered.
6. The aggressively attacked boxer almost died.
7. The properly adjusted brightness revealed the image.
8. The beautifully dressed hostess seated us.
9. The deeply feared darkness was actually harmless.
10. The cleverly tricked tourist cursed.
11. The anonymously identified driver fled the crime.
12. The absurdly overlooked failure shocked the nation.
13. The systematically violated fairness annoyed Bertie.
14. The individually protected freedom was valued.
15. The heroically defeated fighter was buried.
16. The swiftly executed action had repercussions.
17. The strangely cured illness mystified doctors.
18. The skillfully cornered lawyer grimaced.
19. The newly appointed leader spoke.
20. The brilliantly reviewed likeness was displayed.
21. The passionately murdered lover had been lying.
22. The publicly denounced madness was widespread.
23. The massively ignored movement found little funding.
24. The recently deceased owner left no will.
25. The excellently trained player practiced every day.
26. The violently removed poster advertised a protest.
27. The poorly instructed reader mispronounced the word.
28. The badly replaced pavement tripped many runners.
29. The suspiciously investigated payment was reported.
30. The earnestly discussed sadness of Betty.
31. The incredibly talented dancer amazed.
32. The eloquently humiliated speaker blushed.
33. The hygienically prepared treatment was effective.
34. The loudly mocked teacher reprimanded the class.

35. The politely addressed waiter gave excellent service.
36. The quickly injured walker left the race.
37. The painfully exposed weakness was embarrassing.
38. The excitedly celebrated winner calmed the crowd.
39. The carefully watched worker behaved.
40. The comically ridiculed writer hid.
41. The timidly stroked eagle grinned.
42. The accurately translated bible caused controversy.
43. The largely unclaimed bonus was substantial.
44. The unhealthily treated bowel shamed Frank.
45. The lazily disciplined camel would not obey.
46. The secretly packed cargo contained no bananas.
47. The dimly illuminated cellar held the secret.
48. The freshly added charcoal fueled the fire.
49. The elaborately crafted china cracked.
50. The excellently directed choir performed.
51. The popularly acclaimed circus attracted thousands.
52. The historically celebrated colonel won many wars.
53. The loudly played music won awards.
54. The newly purchased diesel fueled the car.
55. The cheaply traded dollar angered nationalists.
56. The horribly handled drama lost viewers.
57. The sadly recalled era had been unpleasant.
58. The vastly expanded furnace heated the room.
59. The strongly preferred garlic added flavor.
60. The initially supervised hour finished unmonitored.
61. The scientifically tested jargon confused students.
62. The brutally killed lion had fought fiercely.
63. The commonly consumed mackerel was oily.
64. The heavily loved mama cooked marvelous food.
65. The beautifully polished marble costs a fortune.
66. The narrowly eroded margin angered Charlie.
67. The newly introduced money confused the Belgians.
68. The badly insulated motel received many complaints.
69. The tightly tied nylon cut off circulation.
70. The royally decorated palace was brash.
71. The wrongly delivered parcel caused a lawsuit.
72. The firmly erected pillar shook.
73. The carelessly treated pupil filed a complaint.
74. The tastelessly marketed soda sold well.
75. The strangely replaced sofa tripped Sally.
76. The easily missed target evaded Bob.
77. The honorably revoked title was missed.
78. The gruelingly debated trial finally ended.
79. The newly acquired vehicle came with maps.
80. The extravagantly adorned villa impressed the visitors.
81. The finely dispersed ash faded away.
82. The terrifically exploited asset was exhausted.
83. The sparsely planted bush grew stripy flowers.

84. The tenderly nursed calf finally woke.
85. The cheaply stored champagne tasted rotten.
86. The colorfully painted clay was priceless.
87. The impressively climbed cliff crumbled.
88. The incorrectly assigned costume was returned.
89. The terribly unexpected death depressed Harold.
90. The fashionably designed device was auctioned off.
91. The aggressively cured disease had proven deadly.
92. The calmly explored forest was quiet.
93. The nobly reached goal raised morale.
94. The magnificently decorated hall impressed everyone.
95. The awkwardly observed cue shamed Barry.
96. The painfully amputated limb was reattached.
97. The terribly announced loss shocked Stan.
98. The badly damaged lung barely functioned.
99. The spaciously constructed mall bankrupted the developer.
100. The nicely served meal had four courses.
101. The finally crossed mile was worth it.
102. The heroically rescued mom cried.
103. The softly eliminated moss returned.
104. The harshly dismissed nun left quietly.
105. The organically fabricated pill can improve health.
106. The desperately delivered plea was not heeded.
107. The dishonestly deceived regime retaliated swiftly.
108. The ingeniously composed rhythm was a hit.
109. The cheerfully welcomed robin entered the bar.
110. The cheaply knotted rug slowly fell apart.
111. The firmly smashed skull was fake.
112. The fairly distributed sum settled the argument.
113. The wrongly diagnosed symptom caused more problems.
114. The excellently marketed system gained popularity.
115. The properly executed technique was safe.
116. The hazardously fenced terrain tempted audacious hikers.
117. The neatly stored tray fell.
118. The correctly adjusted volume suited everyone.
119. The hectically planned week finally ended.
120. The cruelly punished witch threatened revenge.

Unexpected

1. The brilliant promoted artist created a masterpiece.
2. The successful robbed baker cried.
3. The smart ruined banker needed a job.
4. The intense detested boredom lingered on.
5. The proud welcomed bowler entered.
6. The aggressive attacked boxer almost died.
7. The proper adjusted brightness revealed the image.
8. The beautiful dressed hostess seated us.
9. The deep feared darkness was actually harmless.
10. The clever tricked tourist cursed.

11. The anonymous identified driver fled the crime.
12. The absurd overlooked failure shocked the nation.
13. The systematic violated fairness annoyed Bertie.
14. The individual protected freedom was valued.
15. The heroic defeated fighter was buried.
16. The swift executed action had repercussions.
17. The strange cured illness mystified doctors.
18. The skillful cornered lawyer grimaced.
19. The new appointed leader spoke.
20. The brilliant reviewed likeness was displayed.
21. The passionate murdered lover had been lying.
22. The public denounced madness was widespread.
23. The massive ignored movement found little funding.
24. The recent deceased owner left no will.
25. The excellent trained player practiced every day.
26. The violent removed poster advertised a protest.
27. The poor instructed reader mispronounced the word.
28. The bad replaced pavement tripped many runners.
29. The suspicious investigated payment was reported.
30. The earnest discussed sadness of Betty.
31. The incredible talented dancer amazed.
32. The eloquent humiliated speaker blushed.
33. The hygienic prepared treatment was effective.
34. The loud mocked teacher reprimanded the class.
35. The polite addressed waiter gave excellent service.
36. The quick injured walker left the race.
37. The painful exposed weakness was embarrassing.
38. The excited celebrated winner calmed the crowd.
39. The careful watched worker behaved.
40. The comical ridiculed writer hid.
41. The timid stroked eagle grinned.
42. The accurate translated bible caused controversy.
43. The large unclaimed bonus was substantial.
44. The unhealthy treated bowel shamed Frank.
45. The lazy disciplined camel would not obey.
46. The secret packed cargo contained no bananas.
47. The dim illuminated cellar held the secret.
48. The fresh added charcoal fueled the fire.
49. The elaborate crafted china cracked.
50. The excellent directed choir performed.
51. The popular acclaimed circus attracted thousands.
52. The historic celebrated colonel won many wars.
53. The loud played music won awards.
54. The new purchased diesel fueled the car.
55. The cheap traded dollar angered nationalists.
56. The horrible handled drama lost viewers.
57. The sad recalled era had been unpleasant.
58. The vast expanded furnace heated the room.
59. The strong preferred garlic added flavor.

60. The initial supervised hour finished unmonitored.
61. The scientific tested jargon confused students.
62. The brutal killed lion had fought fiercely.
63. The common consumed mackerel was oily.
64. The heavy loved mama cooked marvelous food.
65. The beautiful polished marble costs a fortune.
66. The narrow eroded margin angered Charlie.
67. The new introduced money confused the Belgians.
68. The bad insulated motel received many complaints.
69. The tight tied nylon cut off circulation.
70. The royal decorated palace was brash.
71. The wrong delivered parcel caused a lawsuit.
72. The firm erected pillar shook.
73. The careless treated pupil filed a complaint.
74. The tasteless marketed soda sold well.
75. The strange replaced sofa tripped Sally.
76. The easy missed target evaded Bob.
77. The honorable revoked title was missed.
78. The grueling debated trial finally ended.
79. The new acquired vehicle came with maps.
80. The extravagant adorned villa impressed the visitors.
81. The fine dispersed ash faded away.
82. The terrific exploited asset was exhausted.
83. The sparse planted bush grew stripy flowers.
84. The tender nursed calf finally woke.
85. The cheap stored champagne tasted rotten.
86. The colorful painted clay was priceless.
87. The impressive climbed cliff crumbled.
88. The incorrect assigned costume was returned.
89. The terrible unexpected death depressed Harold.
90. The fashionable designed device was auctioned off.
91. The aggressive cured disease had proven deadly.
92. The calm explored forest was quiet.
93. The noble reached goal raised morale.
94. The magnificent decorated hall impressed everyone.
95. The awkward observed cue shamed Barry.
96. The painful amputated limb was reattached.
97. The terrible announced loss shocked Stan.
98. The bad damaged lung barely functioned.
99. The spacious constructed mall bankrupted the developer.
100. The nice served meal had four courses.
101. The final crossed mile was worth it.
102. The heroic rescued mom cried.
103. The soft eliminated moss returned.
104. The harsh dismissed nun left quietly.
105. The organic fabricated pill can improve health.
106. The desperate delivered plea was not heeded.
107. The dishonest deceived regime retaliated swiftly.
108. The ingenious composed rhythm was a hit.

109. The cheerful welcomed robin entered the bar.
110. The cheap knotted rug slowly fell apart.
111. The firm smashed skull was fake.
112. The fair distributed sum settled the argument.
113. The wrong diagnosed symptom caused more problems.
114. The excellent marketed system gained popularity.
115. The proper executed technique was safe.
116. The hazardous fenced terrain tempted audacious hikers.
117. The neat stored tray fell.
118. The correct adjusted volume suited everyone.
119. The hectic planned week finally ended.
120. The cruel punished witch threatened revenge.