Comparison of Sentential-Stress Allocation within Base Phrases among Different Reading Styles

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Abstract

This paper compares the allocation tendency of sentential stresses within base phrases among four reading styles, *Lyric*, *Critical*, *Explanatory* and *Neutral*. Indicators for stress tendency are defined respectively for words and within phrases to illustrate (1) the possibility for a class of words to obtain sentential stresses on sentence level and (2) which components in a base phrase is easier to obtain stresses. The final conclusions are (1) rhythmic stresses tend to locate on the final words within base phrases, regardless of reading styles; (2) allocation of semantic stresses is affected by the reading styles. The *Explanatory* style shares a similar allocation tendency with the *Neutral* style. The *Critical* style differs from the *Neutral* style mainly in phrases with the adverbial+head structure. The *Lyric* style differs from the other styles in many aspects because, when reading essays in *Lyric* style, the speaker tends to form a kind of poetry-like rhythm to get a better expression of the beauty of the essay.

1. Introduction

Stress, or its substitute, prominence, has been defined as "the degree of force" in terms of speech production [1] or as "the degree of loudness" from the viewpoint of speech perception [2]. It has been ranked into different levels of hierarchy, on the top of which is the most salient sentential stress [3]. The definition of sentential stress varies in past literatures. However, all these definitions can be classified into two groups if the functions of the stress are considered the main factor in delivering messages. Generally speaking, those, as normal stress defined by Newman [4] and Zhao [5], or grammar stress defined by Bolinger [6] and Chomsky [7], to reflect the syntactic or rhythmic structure, are predictable with grammatical [8] or phonological rules [9]. Others, as contractive stress, emphatic stress [10], logical stress, to express speaker's special intentions, are hard to predict without a deep understanding of the context.

In Chu & Wang's recent works [11][12], sentential stress is classified into rhythmic stress and semantic stress. The former serves the purpose of illustrating the rhythmic structure of an utterance and the later of making the speaker's opinion or intention prominent. The validity of the classification has been proven by perceptual experiments. Their study shows that the rhythmic stress tends to be allocated to the last syllable of the last word in a prosodic phrase [11], while no direct relationship has been found between the location of semantic stress and the prosodic structure of an utterance. In a study on semantic stress in Mandarin, Wang *et. al.* [13] found that the allocation tendency of semantic stress changes with the speech unit studied. On the one hand, within a sentence, semantic stress is more often allocated to the predicate part or the objective part (if there exists any) than to the subjective part. However, such tendency does not hold within a base phrase. On the other hand, in a base phrase or a prosodic word, semantic stress is often found to be allocated to the modifiers when the phrase has an attribute+head structure or an adverbial+head structure. Yet, such tendency does not hold in the sentence level. The main difference in the allocation tendency of sentential stress between base phrases and prosodic words lies in that, semantic stress shows final-stress tendency in coordinative structures in base phrases and initial-stress tendency in prosodic words.

So far, conclusions in [11] and [13] are drawn from the observation of independent sentences read with a neutral intonation (referred as a *Neutral* style in the remaining of this paper). In order to verify the generalization of these conclusions, short articles read in three different styles are studied. With the space limitation, only the stress allocation tendencies within base phrases are discussed in this paper, because it is the part that is affected the most by reading styles. The aim of this paper is to investigate which immediate constituent in a certain type of construction tends to acquire sentential stresses in the domain of base phrases and to testify whether rules concluded with neutral independent sentences can hold true in sentences with paragraphic and affective contexts.

2. Data Preparing and Processing

2.1. The speech corpus

7 articles are selected for this study, in which, two are lyric essays by famous Chinese writers, 2 are remarks (one on a newly-published novel and the other on a newly-drawn policy) and 3 are objective illustrations (one on weather, one on stock and one on rules of law). These articles are read by the same voice talent who also read the independent sentences studied by Chu & Wang. Unlike previous recording sessions where the voice talent was asked to read sentences with a neutral intonation, this time, she was requested to choose a proper reading style for each type of articles according to her understanding of these articles. The three reading styles are referred as *Lyric*, *Critical* and *Explanatory* respectively in the remaining of this paper. The validity of the division can be demonstrated by reading speed [14] as given in Table 1. It can be figured out that the *Lyric* style is presented the slowest and

the *Critical* style the fastest. The *Explanatory* style is read with a mezzo speed which is very close to that of the *Neutral* one.

Table 1. *Comparison of the rates of speech among four reading styles.*

Reading Style	Lyric	Criti.	Exp.	Neutral
Length (num. of char.)	897	697	1450	6162
Reading Speed (char/s)	3.5	4.2	3.8	3.7

In order to compare our results to those in [13], similar labeling schemes are adopted. First, sentential stress and its type are identified by two well trained annotators. Then, a structural attribute is assigned to each prosodic word according to what type of immediate constituent it is. The procedure of the labeling are introduced below.

2.2. Identifying stress and its type

Stress labeling is not an easy task. Normally, there are two ways to do it. One is to have many subjects to label the same corpus and to keep the labels with high agreement ratios. The method is reliable, yet labor and time consuming. The other way is to have well trained experts to do the labeling. According to [11], after a training period, a small number of experts working for the same task can achieve reliable results too. Therefore, experts labeling is adopted in this paper.

Two graduate students who major in linguistics, especially in phonetics, are trained on this task. They are first asked to identify all sentential stresses and assign a type (rhythmic, semantic or both) to each stress in a training corpus by listening to utterances under the guidelines in Table 2. The training corpus is a subset of the materials in Chu & Wang's study so that it contains stress labels as reference. The results from the two students are compared with the reference altogether. The initial agreement ratio on both the stress location and the stress type between the two students is only 56.4%. They are asked to discuss on all differences and try to achieve agreement on these variances. After the training stage, the two students are asked to label 20 sentences that are out of the training set. This time, the agreement ratio increases to 67.6%. Then, they start to label stresses in the 7 articles. After the independent labeling, they are again asked to discuss on cases where different opinions appeared. For a few cases where no agreement is reached after discussions, a third person is invited to make final judgments. As a result, each syllable in the 7 articles obtains one of the four stress labels, US — unstress, SS — semantic stress, RS — rhythmic stress, SRS — semantic and rhythmic stress.

Table 2. *Guidelines for identifying stress and its type*

1.	Annotators can listen to a sentence as many times as they want;
2.	At least one stress should be labeled in each sentence, yet, without any constraint on stress type;
3.	No maximum number of stresses is set for a sentence.

2.3. Labeling structural attribute for prosodic word

In order to study the stress allocating tendency in base phrases, the grammatical structure of base phrases are labeled first. To be consistent with Wang *et. al.*'s work [13], structural attribute is labeled for each prosodic word as follows:

a) Identify an immediate construction for each word, i.e. the word should be an immediate constituent of that construction (or base phrase);

b) Assign a structural type to the construction. 7 structural types are predefined which are: ① SP — subject + predicate；②AN — attribute + head (noun); ③ PC — predicate + complement; ④ AV — adverbial + head (verb); ⑤ PO — predicate + object; ⑥ CO — coordinative construction ; ⑦ PP — preposition phrase.

c) Clarify the attribute of the prosodic word in its immediate construction, such as the object in a PO construction or the verb in an AV construction.

As a result, each prosodic word in the corpus is labeled by two attributes, i.e., the structural type of its immediate construction and its attribute within that construction. Each construction contains only two immediate constituents. The labeling procedure is illustrated by Figure 1.
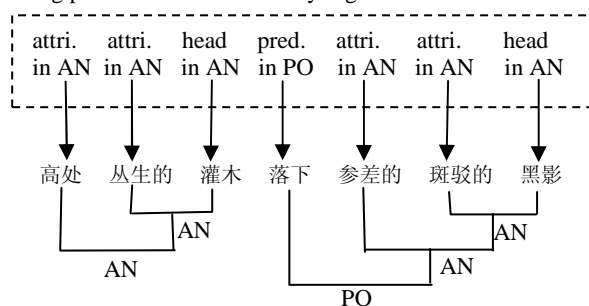

Figure 1. An example of structural labeling for all prosodic words in the sentence "高出丛生的灌木落下参差斑驳的黑影" （"Tufty shrubs in the upland cast spotted irregular shadows."）。

2.4. Indicators for stress tendency

For a certain type of a construction (or a base phrase), the total number of words in one attribute may differ from that in the other attribute. For example, in Figure 1, there are 4 "attri. in AN" while only two "head in AN". Therefore, the ratio of the number of stressed words in "attri. in AN" class to that in the "head in AN" class does not reflect directly the tendency of been stressed, since, if stresses are distributed normally among all words, the ratio is 2:1. Thus, a more suitable parameter should be used.

For describing the possibility for a class of words to obtain sentential stresses, a *stress indicator for word* (SIW) is defined as the ratio of the number of obtained stresses to the expected number of stresses in a certain class of words as in (1).

$$SIW = N_r / N_p \tag{1}$$

where Nr is the number of stresses obtained by a class of words and N_p is the expected number of stresses for the class under the assumption that all stresses are distributed normally among all words in the corpus.

Thus, $SIW > 1$ means that the possibility for the corresponding class of words to obtain stresses is above average, i.e. it has the tendency to obtain sentential stresses. $SIW < 1$ means the

opposite and *SIW* = 1 means it has the average possibility to be stressed. N_p is calculated by (2) and (3).

$$N_p = N_w \times P \qquad (2)$$
$$P = N_s / N_a \qquad (3)$$

where N_a is the number of words in the studied corpus, N_s is the number of stressed words in the corpus, P indicates the possibility of a word to obtain a sentential stress under the normal distribution assumption, N_w is the number of words in a class of word studied.

For illustrating the stress tendency within a certain type of phrase, i.e. which immediate component is more often to be stressed, a *stress indicator within phrase* (SIP) is defined as the ratio of the SIW of the initial component to that of the final component. If *SIP*>1, the corresponding type of phrase has the initial-stress tendency, while, if *SIP*<1, it has final-stress tendency. *SIP*=1 means the two immediate components have the same chance to be stressed.

3. Results and Discussions

3.1. Results and analysis

Since CO and PC constructions appear only a few times in each reading style, only the other five types of constructions, i.e. AN, AV, PP, PO and SP, are studied in this papers. SIW and SIP for words and base phrases in the five categories are calculated separately under the three reading styles. Since the previous studies in [13] adopted a different stress indicator, SIW and SIP is calculated for the Neutral style as well for the sake of comparison. The results are listed in Table 3, in which, (a) and (b) are SIW and SIP for RS, while (c) and (d) are for SS. The words that obtained both SS and RS are used repeatedly in the two categories.

Table 3. *Stress indicators of words and phrases under the four reading styles*

(a) *SIW for RS*

Phrase type	Word attribute	Reading styles			
		Lyric	Criti.	Exp.	Neutral
AN	attribute	0.27	0.18	0.10	0.14
	head	2.24	2.35	2.10	1.84
AV	adverbial	0.42	0.25	0.19	0.46
	head	1.66	1.29	1.57	1.25
PP	preposition	0.00	0.00	0.13	0.09
	object	1.46	1.28	0.88	1.10
PO	predicate	0.22	0.11	0.42	0.50
	object	2.02	2.84	2.42	2.05
SP	subject	0.94	1.71	0.95	1.15
	predicate	2.34	3.85	2.42	2.16

(b) *SIP for RS*

Phrase type	Reading styles			
	Lyric	Criti.	Exp.	Neutral
AN	0.12	0.08	0.05	0.07
AV	0.25	0.18	0.12	0.37
PP	0	0	0.15	0.08
PO	0.11	0.04	0.17	0.25
SP	0.40	0.44	0.39	0.53

(c) *SIW for SS*

Phrase type	Word attribute	Reading styles			
		Lyric	Criti.	Exp.	Neutral
AN	attribute	1.22	1.50	1.39	1.31
	head	1.52	0.95	0.98	0.93
AV	adverbial	0.81	1.05	1.17	1.33
	head	1.05	1.09	0.93	1.00
PP	preposition	0.37	0.00	0.00	0.04
	object	0.78	0.98	0.83	1.20
PO	predicate	0.65	0.34	0.44	0.48
	object	1.61	1.54	0.57	1.65
SP	subject	0.74	0.33	0.63	0.70
	predicate	0.78	1.96	2.04	1.68

(d) *SIP for SS*

Phrase type	Reading styles			
	Lyric	Criti.	Exp.	Neutral
AN	0.81	1.58	1.42	1.42
AV	0.76	0.96	1.26	1.33
PP	0.48	0	0	0.03
PO	0.40	0.22	0.77	0.29
SP	0.95	0.17	0.31	0.42

From Table 3(a)-(b), final-stress tendency is observed unanimously of RS allocation, regardless of reading styles. In Table 3(a), most words on the initial positions of phrases have SIWs much smaller than 1, i.e. their possibilities of obtaining RS are below average, while most words on the final positions have SIWs much larger than 1, i.e. their possibilities to obtain RS are above average. Exceptions for words on initial positions are found in SP phrases, in which subjects have SIWs close to or larger than 1. The only exception for words on the final positions is the object in PP phrase under the explanatory style. However, in both situations, the SIWs of initial words are still smaller than those of final words, i.e. the final-stress tendency is still hold. This can be seen more clearly in Table 3(b), in which all SIPs are much smaller than 1. This is consistent with the conclusions drawn from independent neutral sentences [11], and it further demonstrates that the final-stress tendency of RS does not been influenced by reading styles. It is worth noticing that SP phrases in all the four reading styles always have the largest SIPs among all types of phrases, i.e., the final-stress tendency is comparatively weak in SP phrases. A possible reason for this phenomenon might be that, when words are grouped into prosodic phrases, the relationship between the subjects and the predicates in SP phrases is looser so the two components are often grouped into different prosodic phrases [15].

The results for SS in Table 3(c)-(d) show much diversity.

(a) In AN phrases, all initial words have SIWs larger than 1 and final words have SIWs close to or larger than 1. All SIPs for AN phrases, except that under the *Lyric* style, are larger than 1. This shows that AN phrases normally have more chances to obtain SS and SS tends to be allocated to the attribute part. However, when under a *Lyric* style, the heads in AN phrases have more chance to obtain SS.

(b) In AV phrases, both immediate constituents have SIWs close to 1. Among the four reading styles, *Explanatory* and *Neutral* ones show initial-stress tendency, while the

Lyric style has final-stress tendency. The chances of being stressed for both components under a *Critical* style are almost the same.

(c) PP phrases normally have few chances to obtain SS and they all demonstrate strong final-stress tendency. Under *Critical*, *Explanatory* and *Neutral* styles, prepositions in PP phrases are seldom stressed. However, under a *Lyric* style, prepositions obtain SS in some cases.

(d) In PO phrases, predicates have few chances and objects normally have above-average chances to obtain SS, except those under the explanatory style. All SIPs for PO phrases are smaller than 1, i.e., PO phrases have final-stress tendency. Among the four reading styles, the final-stress tendency of PO phrase is weaker under the *Explanatory* style.

(e) Under *Critical*, *Explanatory* and *Neutral* style, SP phrases show strong final-stress tendency. Yet, under *Lyric* style, the two immediate constituents of SP phrases have equal chance to obtain SS.

Comparing relevant items under the *Neutral* style with those under the other three reading styles, we found that SS allocation under the *Explanatory* style resembles most to that of *Neutral* style. The only difference between them is that the weakening of final-stress tendency in PO phrase under the *Explanatory* style. The *Critical* style has similar tendency to that of the *Neutral* style in most cases. The main difference between the two is that, instead of having initial-stress tendency, the AV phrase in *Critical* style shows equal chance for its two immediate components to obtain stresses. The *Lyric* style demonstrates many differences to the *Neutral* one. All phrases under this reading style have final-stress tendency to some extent.

3.2. Discussions

When reciting an essay (with the *Lyric* style), the speaker normally tends to form a kind of poetry-like rhythm to get a better expression of the beauty of the essay. Such poetry-like rhythm on the one hand weakens the effect of syntactic constrains and on the other hand, adjusts the location of semantic stress within base phrases to meet the requirement of rhyme-scheme [16].

When reading critical articles, the speaker often wants to emphasize the subjective opinions on the topic discussed. Such opinions are generally revealed by the verbs selected. Therefore, in the *Critical* style, verbs have more chances to be stressed. As a result, the initial-stress tendency of SS in AV phrases is trailed off.

In *Explanatory* style, the speaker's task is to present messages clearly and concisely with an objective tone. This is also a regular way to deliver independent neutral sentences where syntactic constraints work actively. Hence, the tendency of SS allocation under this style is very close to that under the *Neutral* style.

4. Conclusions

The paper investigates the allocation of sentential stresses within base phrases among different reading styles. The results show the final-stress tendency of RS is valid in all five types of constructions, regardless of reading styles. The final-stress tendency of SS is shared in PP and PO phrases among the four reading styles. In cases of AN, AV and SP phrases, variance occurs to accord with features of each style. The neutral

sentence has initial-stress tendency in AN and AV phrases, but final-stress tendency in SP phrases. The explanatory style resembles most to that of neutral sentences in terms of the SS allocation. The *Critical* style also shows similar tendency to the *Neutral* style except that it has no stress tendency in AV phrases. The *Lyric* style differs from the others in many aspects, such as AN and AV phrases show final-stress tendency and no special stress preference exists on either immediate components of SP phrases.

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