

Effect of Relative Frequency of Lexical Meanings on Accessing Lexical Ambiguities: Evidence from the Coordinator ‘and’

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Abstract—Lexical ambiguity is a common phenomenon in English. Research on the resolution of lexical ambiguity began since 1970s, and has developed several theories on how comprehenders settle on a single meaning [12, 21, 28, 30]. Many studies have investigated the effects of relative meaning frequency and other factors on lexical ambiguity resolution [27, 29, 36], while the research subjects are mainly content words. Whether there are effects of relative meaning frequency on accessing coordinators keeps unclear. The present study takes the coordinator ‘and’ as the research subject to explore the effect of relative meaning frequency on lexical access via a lexical decision task and further investigate whether related meanings of ‘and’ lead to confusions in lexical access. In the experiment, 21 participants who are advanced Chinese EFL learners were requested to choose one of the two meanings for ‘and’ which connects two clauses in a complex sentence, and the accuracy and reaction time (RT) were collected. It was found that relative meaning frequency did influence accessing meanings of coordinator ‘and’—the higher the relative meaning frequency, the shorter the response time, and the relatedness between meanings led to confusions in lexical access. These results confirm the effect of relative meaning frequency on accessing meanings of coordinators and reveal the importance of distinguishing the related meanings.

I. INTRODUCTION

A. Background

There is not always one-to-one mapping between word senses and lexical forms. Most words have multiple meanings. Reference [3] reported that 44 percent of a random sample of English words had more than one dictionary definition. Reference [35] has made a classification for ambiguous words: homonymy and polysemy. Homonymy is a term referring to two words sharing the same orthography and phonology, but with totally different and unrelated meanings [11, 22] (like *bark*, referring to the outer layer of a tree or to the sound that a dog makes). This type of homonymous word also can be termed a homophonic homograph [23]. How homophonic homographs come about (whether historical relations or accidental coincidence of spelling and sound) is of no consequence to lexical access [7]. Ambiguity between related meanings is known as polysemy, considering the word *door* in the following sentences [1]:

- (1) The door fell off its hinges.
- (2) The child ran through the door.

The *door* in sentence (1) denotes a physical object, while it refers to an aperture in sentence (2). The two senses are related.

Research on the resolution of lexical ambiguity began since 1970s. Many studies have investigated the effects of relative meaning frequency and other factors on lexical ambiguity resolution [27, 29, 36], and four models have been proposed until now: multiple access model, selective access model, order access model, and reordered access model [36]. In accordance with the multiple access model (or “exhaustive access model”), multiple meanings of an ambiguous word are initially activated, and then one of the activated meanings is selected for sentence comprehension in accordance with the context. This model has accommodated much data from many experiments [10, 37]. However, this model is not without problems. In spite of the ample evidence for multiple activations, it is found that the context-inappropriate meaning is activated more slowly than the context-appropriate meaning [2, 14]. According to selective access model, one meaning of an ambiguous is retrieved, which is determined by the context in which the word occurs, and its strong form even denies the processing of context-inappropriate meanings [12, 27]. However, the activation for context-inappropriate meanings has found in many studies [5, 20]. In line with the order access model [18, 33], only one meaning is initially retrieved. If this meaning is consistent with the context, no further meanings are retrieved. If not, an alternative meaning is searched. The order of retrieval is assumed to be determined by relative meaning frequency. According to the reordered access model [15-16, 28], meanings of an ambiguous word are serially activated on the basis of lexico-semantic factors such as relative meaning frequency and context. To be specific, if an ambiguous word has strongly polarized meanings, the most frequent meaning will be activated first, followed by the less frequent meaning [19]. But a strongly biasing sentential context can serve to re-order the sequence of the activation of multiple meanings; so even a less frequent meaning may be activated first.

Studies on both accessing homophonic homographs and polysemous words have proved the effects of relative meaning frequency on lexical ambiguity resolution [27, 29, 36]. After verification, it is found that the research subjects of above researches are mainly content words. English is

hypotactic, and the relation between conjoins is expressed through formal cohesion, such as coordinators [32]. However, coordinators are often skipped during reading [17]. So investigation for the effect of relative meaning frequency on accessing coordinators is of great interest. Polysemy ‘and’, a coordinator with the most general meaning and use [26], is taken as the research subject to explore the effect of relative meaning frequency on lexical access.

B. Relative meaning frequency

In logical terms, ‘and’ merely conveys (for declarative clauses) that if the whole sentence is true, then each of its conjoined clauses is true [26]. But the pragmatic implications of the combination vary, according to our presuppositions and knowledge of the world. So Quirk et al. use the term ‘connotation’ intending to indicate multiple meanings of ‘and’, which present different relations between conjoins. Quirk et al. give eight types of connotations to ‘and’ [26]:

- (a) The second clause is a SEQUENCE or RESULT of the first;
He heard an explosion and he (therefore) phoned the police.
- (b) The second clause is chronologically SEQUENT to the first, but without any implication of a cause-result relationship;
I washed the dishes and (then) I dried them.
- (c) The second clause introduces a CONTRAST;
Robert is secretive and (in contrast) David is candid.
- (d) The second clause is felt to be surprising in view of the first, so that the first clause has a CONCESSIVE force;
She tried hard and (yet) she failed.
- (e) The first clause is a CONDITION of the second;
Give me some money and (then) I’ll help you escape.
- (f) The second clause makes a point SIMILAR to the first;
A trade agreement should be no problem, and (similarly) a cultural exchange could be easily arranged.
- (g) The second clause is a ‘pure’ ADDITION to the first, the only requirement being that the two statements are congruent in meaning;
He has long hair and (also) he often wears jeans.
- (h) Similar to (g) is a sentence in which the second clause adds an appended COMMENT on or EXPLANATION of the first.
They disliked John – and that’s not surprising in view of his behavior.
There’s only one thing to do now – and that’s to apologize.

It is obvious that “the relation connected by the link between the two conjoins can generally be made explicit by the addition of an adverbial [26]”.

Three hundred complex sentences connected by ‘and’ were selected randomly from Chinese Learner English Corpus [31]. The meaning of each coordinator ‘and’ was then analyzed by the writer and the other two appraisers, one of them is a native English professor following the classification of the sentence-medial ‘and’ by Quirk et al. Finally we ordered the eight meanings by the usage frequency of the random sample:

ADDITION > SEQUENCE > RESULT > CONTRSAT > SIMILAR > COMMENT OR EXPLANATION > CONCESSION > CONDITION. The result accommodates the data from another research [4].

We took ADDITION, SEQUENCE, RESULT (relative high-frequency) and COMMENT OR EXPLANATION, CONCESSION, CONDITION (relative low-frequency) as target meanings, and CONTRSAT, SIMILAR as fillers to explore the effect of relative meaning frequency on accessing coordinator ‘and’. Due to the relatedness between the target meanings, we further investigate whether related meanings of ‘and’ lead to confusions in lexical access.

In line with the reordered access model, we hypothesized that in weakly biasing sentential context the speeds of lexical access for ADDITION, SEQUENCE and RESULT meanings would be faster than COMMENT OR EXPLANATION, CONCESSION and CONDITION meanings.

II. METHOD

A. Participants

Twenty-one postgraduates of foreign linguistics & applied linguistics with normal or corrected-to-normal vision were recruited via the Nanjing University of Science & Technology (NJUST). All participants had passed TEM-8 and were paid a small amount for their participation.

B. Stimuli

The experiment used here was a lexical decision paradigm. Participants read a complex sentence silently, and then chose one of the two meanings for coordinator ‘and’ in each complex sentence. One factor was manipulated in the experiment: the relative frequency of meanings of coordinator ‘and’ (high vs. low). The accuracy and RT in this task were recorded.

Sentences in this experiment were selected from Chinese Learner English Corpus [31]. A total of 56 complex sentences connected by coordinator ‘and’ were obtained, of which 30 experimental sentences, and 26 filler sentences. Additionally, there were 7 additional sentences to familiarize the participants with the experiment.

These 56 sentences were manipulated in terms of sentences length, word length, word frequency, sentential context and sentence structure. First, all stimuli were 12-word-long sentences. Second, word length and word frequency in the same location of the 56 sentences were controlled: the difference of word length was within 3 letters (e.g. The word length of initial words in all sentences is between 2-letter and 5-letter. For more details see TABLE I); frequencies of words in the same location were between means ± 3 SDs. Third, according to Quirk et al.: “the relation connected by the link between the two conjoins can generally be made explicit by the addition of an adverbial [26]”, adverbials in sentences were all deleted to create the weakly biasing sentential context in this study. Finally, the sentences were of a very common syntactic structure, and stayed the same (See TABLE I). Note that only imperative structure can be used for CONDITION meaning, inconsistent with the sentence

structure of other meanings. CONDITION meaning was deleted from consideration. Therefore, there are 42 complex sentences in this study, of which 20 experimental sentences, and 22 filler sentences.

There were two options for each sentence, and the collocation of each two-option followed the method of arrangement and combination. Examples are shown in TABLE I. In order to avoid sequence effect, each sentence was presented twice, only the order of two options changed. So in this task each participant read 84 sentences.

TABLE I
SENTENCES AND OPTION COLLOCATION IN THE EXPERIMENT:
TAKE SEQUENCE MEANING AS EXAMPLES

She washes many clothes, and she dries clean clothes in the yard. 1 sequence 2 contrast
They clean many vegetables, and they cook great breakfast for the family. 1 sequence 2concession
She takes great breakfast, and she writes French homework in the room. 1 sequence 2 comment or explanation
They return small apartment, and they take nice showers in no time. 1 sequence 2 similar
She takes great relaxation, and she starts further survey in no time. 1 sequence 2 addition
They finish hard homework, and they take great relaxation in the room. 1 sequence 2 result

C. Procedure

We used a lexical decision paradigm task. The task was presented with E-Prime 2.0 on a PC, and this experiment was conducted in Language Cognition and Speech Science Lab in NJUST. Participants were seated individually in front of a computer screen in a soundproof room. At the beginning of the experiment, participants were instructed to put the left index finger and right index finger on the key ‘F’ and key ‘J’ respectively, and the thumbs on the space key.

The experiment included two stages, silent reading and lexical decision. The self-paced reading (SPR) method [7, 8] was used in the reading stage. A trial was introduced by twelve graphical masks – twelve strings of ‘-’ characters in the reading stage. Each of the masks hid one of the words

from the sentence to be presented, and the length of each string was of the same size as the word it was masking. Participants commenced the reading by clicking the space key, which unmasked the first of the words. After its reading, participants would click the space key again, which would reveal the next word in the sentence. Fig. 1 shows five steps during the presentation of a twelve-word sentence that was used in silent reading stage (complete sentence: “She washes many clothes, and she dries clean clothes in the yard”). After silent reading was the lexical decision task stage. The complete sentence and two options were on the center of the screen (Fig. 2), and participants would make a choice for the sense of coordinator ‘and’ as quickly and accurately as possible, pressing “F” for option 1, and “J” for option 2.

Participants were first given a practice session of 7 sentences items to help familiarize them with the task. Also, 84 sentences items in experiment session were presented in three separate blocks, and there was a brief break for participants between each stimuli block. The order of presentation of the stimuli was randomised within the block.

Accuracy and RT were recorded by E-prime in this experiment. The RT was measured from the ending of reading until key pressing (or responses making).

III. RESULTS

The data of filler sentences were not collected. Data from one participant were not included in analysis because of an error rate of more than 40%. Of the remaining 20 participants for RT analysis and confusion analysis, the overall error rate for responses was 9.5%, ranging from 5% to 15% for each participant.

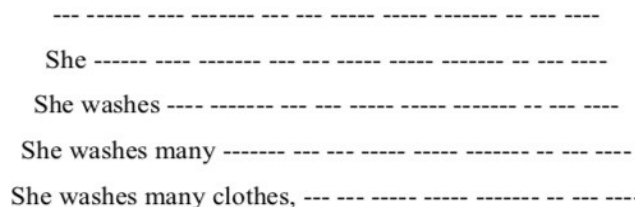


Fig. 1 Five steps in the presentation of a twelve-word sentence

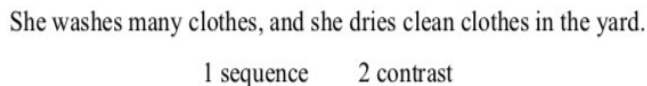


Fig. 2 Lexical decision stage.

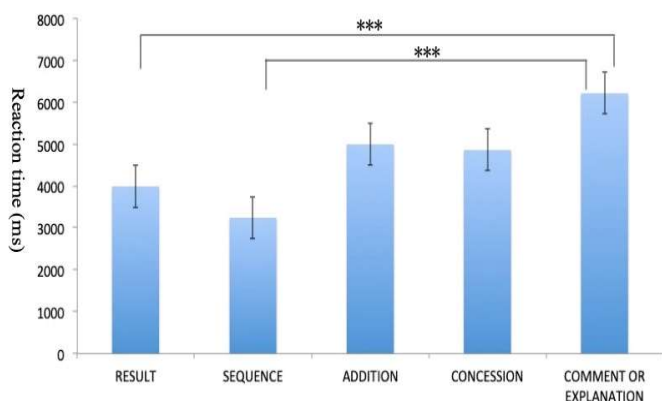


Fig. 3 Mean RT for accessing the five target meanings in the first presentation in lexical decision stage.

A. Reaction time

RTs of correct responses in the first presentation of the experimental sentences were submitted to statistical analysis. A one-way between subjects ANOVA was conducted using SPSS (version 25). Participants' RT was set as the dependent variable. Relative meaning frequency [five levels: ADDITION, SEQUENCE, RESULT (relative high-frequency) and COMMENT OR EXPLANATION, CONCESSION (relative low-frequency)] was set as the independent variable. There was a significant effect of relative meaning frequency on lexical access speed for the five conditions [F(4, 357)=6.533, $p<0.001$]. Post hoc comparisons using LSD test were conducted to compare the difference in RT between each two conditions (ADDITION, SEQUENCE, RESULT, COMMENT OR EXPLANATION, CONCESSION) (Fig. 3). A Bonferroni correction was applied to adjust the threshold of p -value to 0.01 (0.05/5) though this adjustment was considered too conservative [34]. Post hoc test results show that the mean score of RTs for the RESULT condition was significantly different than that of the COMMENT OR EXPLANATION condition ($p<0.001$); the mean score of RTs for the SEQUENCE condition was significantly different than that of the COMMENT OR EXPLANATION condition ($p<0.001$). However, there was no significant difference in other each two-condition.

Note that the mean score of RTs for ADDITION (Mean=4993, SD=3526) was relatively longer among three relative high-frequency meanings. And the mean score of RTs for CONCESSION (Mean=4854, SD=5154) was relatively shorter than the other relative low-frequency meaning.

B. Confusion patterns

In this experiment, each sentence was presented twice. The two choices by participants between the first and second representations were different in next five types of option-collocations, RESULT - SEQUENCE, CONCESSION - SEQUENCE, CONCESSION - RESULT, RESULT - COMMENT OR EXPLANATION, and ADDITION - COMMENT OR EXPLANATION (TABLE II).

The error rates and accuracy of responses in the first presentation are shown in TABLE III. It indicated that the accuracy rate for RESULT meaning was 90%, and the percentage of making an incorrect selection for SEQUENCE was 10%; there was no wrong selection for SEQUENCE meaning; the accuracy rate for ADDITION meaning was 90%, and the percentage of making an incorrect selection for COMMENT OR EXPLANATION was 10%, and so forth.

TABLE II PERCENTAGES OF DIFFERENT CHOICES BETWEEN TWO PRESENTATIONS

Option - collocations	Numbers	Percentages
RESULT - SEQUENCE	5	1.25%
CONCESSION - SEQUENCE	3	0.75%
CONCESSION - RESULT	4	1%
RESULT - COMMENT OR EXPLANATION	2	0.5%
ADDITION - COMMENT OR EXPLANATION	6	1.5%

TABLE III CONFUSION MATRIX OF THE FIRST PRESENTATION

	RESULT	SEQUENCE	ADDITION	CONCESSION	COMMENT OR EXPLANATION
RESULT	72 (90%)	8 (10%)	0	0	0
SEQUENCE	0	80 (100%)	0	0	0
ADDITION	0	0	72 (90%)	0	8 (10%)
CONCESSION	14 (17.5%)	4 (5%)	0	62 (77.5%)	0
COMMENT OR EXPLANATION	4 (5%)	0	0	0	76 (95%)

IV. DISCUSSION

The study reported in this paper sought to investigate whether there was effect of relative meaning frequency on accessing coordinator 'and', and further explored whether related meanings of 'and' lead to confusions in lexical access.

In the current study, the mean score of RTs for COMMENT OR EXPLANATION meaning (relative low-frequency) was significantly longer than RESULT and SEQUENCE meanings (relative high-frequency). Thus, the results replicate the results of Zhao [6] that content words accessing by advanced Chinese EFL learners was mainly influenced by relative meaning frequency in weakly biasing sentential context, and also prove that the more frequent the meaning, the stronger the connection from orthography or phonology to

the semantic level [19].

The access speed for the low-frequency meaning, CONCESSION, was relatively shorter compared with COMMENT OR EXPLANATION meaning. In order to explain this result, we introduce the noticing hypothesis [24-25] here. It believes that noticing is the necessary and sufficient condition for converting input to intake, and frequency is important in this conversion. In line with the definition of CONCESSION meaning by Quirk et al. [26], the translation equivalent of it in Chinese is *'suiran, danshi'* (although). Besides coordinator 'and', Chinese EFL learners also use "although...but" to express CONCESSION meaning due to the negative transfer of Chinese [9, 13]. Therefore, the right expression of CONCESSION meaning is always emphasized by English teachers and also becomes the key point in tests in China. Double emphasis for CONCESSION meaning during second language acquisition explains the rapid access for CONCESSION meaning by most participants in this study. However, there were a few participants accessing this meaning slower in this study. The great difference between the two sides in the RT explains why the SD was larger than the Mean in CONCESSION meaning.

The access speed for the high-frequency meaning, ADDITION, was relatively slower, compared with the other two high-frequency meanings. It was possible the difference between hypotaxis (English) and parataxis (Chinese). English is a language emphasizing overt cohesion so cohesive ties are usually employed in English, i.e. English is hypotactic [32]. For example, "*He has long hair, and he often wears jeans*". However, Chinese is paratactic emphasizing covert cohesion, the arranging of clauses one after the other without connectives showing the relation between them [32]. Example: "*He has long hair, he often wears jeans.*" The ADDITION meaning can be expressed without coordinator 'and' in Chinese, while in English 'and' is essential in expressing ADDITION meaning. Therefore, accessing this meaning by Chinese EFL learners was relatively slower.

The confusion matrix (TABLE III) indicated that advanced Chinese EFL learners confused RESULT with SEQUENCE, CONCESSION with SEQUENCE, CONCESSION with RESULT, ADDITION with COMMENT OR EXPLANATION, and COMMENT OR EXPLANATION with RESULT. The overlapping relations among these meanings can explain the results.

According to the definitions of SEQUENCE and RESULT mentioned above, the RESULT meaning embodies both a sequence and a cause-result relationship while SEQUENCE meaning doesn't implicate a cause-result relation. Such an overlapping relation made participants sometimes confuse RESULT meaning with SEQUENCE meaning. "The second clause is felt to be surprising in view of the first, so that the first clause has a CONCESSIVE force [26]", the definition of CONCESSION shows that this meaning also implicates a result, but an unexpected result. Therefore, it was not surprising that participants confused this meaning with RESULT and SEQUENCE. In line with the definition of COMMENT OR EXPLANATION: "Second clause adds an

appended COMMENT on or EXPLANATION of the first [26]", the sentence structure of this meaning is "result + and + cause". On the contrary, the sentence structure of RESULT meaning is "cause + and + result". These two meanings all implicate a cause-result relationship, but changing the order of them. Such an overlapping relation of these two meanings confused the participants. Finally, on the basis of the definitions of ADDITION and COMMENT OR EXPLANATION by Quirk et al. [26], ADDITION meaning refers to "the second clause in a complex sentence is a pure addition to the first clause [26]", and COMMENT OR EXPLANATION meaning is "Similar to ADDITION is a sentence in which the second clause adds an appended COMMENT on or EXPLANATION of the first [26]". To a certain extent, the second clause in a complex sentence is an addition to the first clause whether coordinator 'and' denotes the ADDITION meaning or refers to the COMMENT OR EXPLANATION meaning. Accordingly, participant sometimes confused ADDITION meaning with COMMENT OR EXPLANATION meaning in this experiment.

Above interpretations can also explain why participants made two different choices for an identical sentence between the first and second presentations when the option-collocations are RESULT - SEQUENCE, CONCESSION - SEQUENCE, CONCESSION - RESULT, RESULT - COMMENT OR EXPLANATION, ADDITION - COMMENT OR EXPLANATION. Therefore, the overlapping relation among multiple meanings produced a negative effect on lexical access, leading to wrong access.

V. CONCLUSIONS

This study aims to investigate whether the relative meaning frequency can influence accessing coordinator 'and', and further explore whether related meanings of 'and' lead to confusions in lexical access. The results strongly support two conclusions. First, the results add to the growing body of evidence supporting the reordered access model that in weakly biasing sentential context, the multiple meanings of an ambiguous word are activated serially based on the relative meaning frequency. At the same time, the results also indicate that the relative meaning frequency not only influences accessing content words but also has an impact on accessing coordinators. Second, related meanings of 'and' can lead to confusions in lexical access. Specifically, semantic overlap produces a negative effect on lexical access, leading to wrong access finally.

The current study presents clear evidence that the relative meaning frequency has an impact on coordinators. Future studies should investigate whether the strength of sentential context can influence accessing coordinators. Moreover, this study suggests the importance of distinguishing the overlapping meanings of an ambiguous word clearly during second language acquisition.

In spite of careful design and planning before this experiment, a limitation is the dataset is relatively small in terms of stimuli due to time limit, which will be improved in the future studies.

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Appendix Stimuli

RESULT:

1. They finish hard projects, AND she gets high praises in the last.
1 result 2 addition
2. They direct hard operations, AND she gets great outcomes in the last.
1 result 2 sequence
3. She refuses simple requests, AND she gets serious criticism from the boss.
1 result 2 contrast
4. She anger kind professors, AND she gets serious punishment in the school.
1 result 2 concession
5. There exists many enemies, AND she calls enough soldiers in no time.
1 result 2 similar
6. They commit many mistakes, AND people refuse silly leadership in the last.
1 result 2 comment or explanation

SEQUENCE:

1. She washes many clothes, AND she dries clean clothes in the yard.
1 sequence 2 addition
2. They clean many vegetables, AND they cook great breakfast for the family.
1 sequence 2concession
3. She takes great breakfast, AND she writes French homework in the room.
1 sequence 2 comment or explanation
4. They return small apartment AND they take nice showers in no time.
1 sequence 2 result
5. She takes great relaxation, AND she starts further survey in no time.
1 sequence 2 contrast
6. They finish hard homework, AND they take great relaxation in the room.
1 sequence 2 similar

ADDITION:

1. They enjoy quiet reading, AND they take enough exercise in daily life.
1 addition 2 sequence
2. She receives enough funding, AND she gets great courage all the way.
1 addition 2 comment or explanation
3. She gives many classes, AND she holds several seminars in this year.
1 addition 2 contrast
4. She leaves many objects, AND she leaves large vehicles on the way.
1 addition 2 result
5. She joins local charity, AND she invests large projects in this year.
1 addition 2 similar
6. She receives great advices, AND she obtains full

supports from her family.

1 addition 2 concession

CONTRAST:

1. She receives wide support, and they lose popular supports in the race.
1 contrast 2 addition
2. They enjoy nature landscape, and she likes cultural landscape in daily life.
1 contrast 2 concession
3. They express wrong arguments, and she shares clear opinions in the class.
1 contrast 2 similar
4. They enjoy open discussion, and she enjoys alone thinking in the class.
1 contrast 2 sequence
5. They save many savings, and she spend total salaries in daily life.
1 contrast 2 result
6. They proved agreed promise, and she broke agreed promise in the last.
1 contrast 2 comment or explanation

CONCESSION:

1. They gain great victory, and they lose wide supports in the last.
1 concession 2 sequence
2. She takes many lessons, and she gets poor outcome in the exam.
1 concession 2 contrast
3. They receive free admission, and they refuse great chances in the last.
1 concession 2 addition
4. They receive little salaries, and they gain wide experience in that firm.
1 concession 2 comment or explanation
5. They receive hard missions, and they obtain great outcome in the end.
1 concession 2 similar
6. They waste full strength, and they adopt serious attitude to the end.
1 concession 2 result

SIMILAR:

1. He offered direct advices, and she offered great comments in the meet.
1 similar 2 addition
2. They achieve great results, and she gains perfect outcome in the exam.
1 similar 2 contrast
3. She benefits high profits, and others gain great advantages in the last.
1 similar 2 concession
4. She dislikes hard statistics, and others hate tough discipline in the class.
1 similar 2 result
5. She receives high reputation, and others accept high

prestige in this field.

1 similar 2 sequence

6. He faces hard choices, and she faces serious dilemma in the career.

1 similar 2 comment or explanation

COMMENT OR EXPLANATION:

1. They maintain enough exercise, and they want hard muscles in the last.

1 comment or explanation 2 similar

2. They develop full resistance, and they want real democracy in this country.

1 comment or explanation 2 contrast

3. They express main content, and they grasp basic concepts to some degree.

1 comment or explanation 2 concession

4. There existed many problems, and they affect main outcome to some degree.

1 comment or explanation 2 addition

5. They exclude those colleagues, and they reflect true reality to some degree.

1 comment or explanation 2 result

6. They maintain great spirits, and that helps great recovery at this stage.

1 comment or explanation 2 sequence