An Investigation of Accuracy and Response Time Regarding Processing Mechanism of English Relative Clauses in EFL Contexts

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Abstract
Sentence comprehension in EFL (English as a Foreign Language) contexts is influenced by many factors. One of the most important ones is the processing mechanism of relative clauses which can be analyzed in different frameworks by researchers. So far, a wide range of research has been conducted on the processing mechanism of relative clauses in a number of languages. The results have shown a tendency toward two major categories which have been proven to be of significance, namely subject preference and object preference. Studies conducted on native speakers of English, for instance, have demonstrated subject preference by the participants. Consequently, in this study, the researchers conducted a self-paced reading experiment employing Linger software, and the data were analyzed by using the SPSS Statistics version 25. It aims to investigate the processing mechanism of English relative clauses by Iranian EFL learners. The participants were nine males and 21 females of advanced English learners majoring in the English literature, all being native speakers of Farsi. The results indicate that that the correctness percentage of subject relative clauses, and also subject modifying ones, are significantly higher than that of object ones. The results also indicated that

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subject relatives were processed swifter than object relatives. Finally, the researchers discussed the reasons behind such a tendency among the participants of the experiment in terms of a number of theories and principles. The findings of this study are expected to be employed in language syllabus designing as well as in grading or sequencing of materials by educators and teaching material developers.

1.   INTRODUCTION

On account of different grammatical and lexical elements that relative clauses can have, this structure indeed calls for a significant level of cognitive resources to process, which places a greater burden on working memory as well. Relative-clause structures are quite common across most languages. The structures of relative clauses are, actually, divergent across languages. For instance, Hoge et al. (2004) point out various types of relative clauses in different languages such as English, Mandarin, Japanese, as well as Arabic, and then suggested that, as a matter of fact, non-uniform formal structures and derivations for relative clauses in different languages do exist (e.g. head raising vs. operator movement, adjunction vs. complementation, etc.). Three typological aspects regarding the structure of relative clauses are of main concern when it comes to research. In general, it can be said that an investigation of the structure of relative clauses can revolve around the head position (e.g. head-initial vs. head-final), basic word orders (e.g. SVO vs. SOV), and/or relativizers. This research is among the realm of the second type, which is basic word orders, however, in terms of its comprehension and processing.

Sentence comprehension research has been of great concerns for linguists, psychologists and educators for a long time; however, the processing mechanism of relative clauses has rather scarcely been the focus of studies by scholars in the field of language learning and teaching. Friedmann and Novogrodsky (2004), for example, investigated comprehension of relative clauses in Hebrew schools, in which subject- and object-relatives was gaged employing binary sentence-picture matching tasks. An important factor in comprehension and processing of relative clauses is the perception of sentences, with regard to their pronouns and references, whether they are in subject relatives or object. Biber et al. (1999) define relative clauses as a subordinate clause which modifies a noun or noun phrase (NP) in an associated main clause. They concluded that two features typically characterize the structure of a relative clause:

(1) The syntactic role of the main-clause element functioning as the head of the relative clause (i.e., the element that is modified by a relative clause). For example: 'The father ran to the child that played with the babysitter and hugged him'.
The syntactic role of the main clause element (child) in the above example is the object of the sentence.

(2) The syntactic role of the element that is gapped or relativized inside of the relative clause (also called the focus of the relative clause). For example: 'The father ran to the child that played with the babysitter and hugged him'.

The syntactic role of the gapped element inside the relative clause above (the child played with babysitter) is the subject of its clause.

Drawing on the features outlined above, Biber et al. (1999) have also gone further, proposing a categorization as follows:

(1) SS relatives, in which the main-clause subject is modified by a relative clause in which the subject is relativized.
Example (1): 'The guy that argued with his brother talked to his friend and killed him'.

(2) SO relatives, in which the main-clause subject is modified by a relative clause in which the object is relativized.
Example (2): 'The guy that his brother argued with talked to his friend and killed him'.

(3) OS relatives, in which the main-clause object is modified by a relative clause in which the subject is relativized.
Example (3): 'The friend talked to the guy that argued with his brother and killed him'.

(4) OO relatives, in which the main-clause object is modified by a relative clause in which the object is relativized.
Example (4): 'The friend talked to the guy that his brother argued with and killed him'.

Since a long time ago, linguists as well as psycholinguists, have always looked for a universal which can be applied to different contexts regarding the language processing preference in subject relatives and object relatives. Based on what has been found in the previous studies, processing of English subject relatives, as a matter of fact, is far easier compared to object relatives (Gibson, 1998; Traxler et al., 2002). The subject-preference perception just mentioned is backed by other Indo-European languages such as German (Schriefers et al., 1995) and Dutch (Mak et al., 2002). Nevertheless, the concept of subject preference has received, to the best knowledge of the researchers, no challenge whatsoever in Iran. There seems to be a clear gap in the investigation of processing mechanisms of relative clauses of different forms used by students of English whose mother tongues are different from the ones already studied, as it was mentioned above. This study is conducted to investigate and draw an analogy between perception of relative clauses and the way they are used and situated in an English sentence by Iranian advanced learners of English. The major center of attention of the present study is basically sentence processing with regard to relative clauses

1.2 Theoretical Grounding

The study is based on the two factors in the structure of a given relative clause, namely, 'embeddedness' and 'focus' (Biber et al., 1999), which can be of importance in the processing as well as producing a relative clause by EFL learners and even native speakers (King & Just, 1991). Embeddedness, chiefly, addresses the position of a given relative clause compared to the sentence. It can be categorized into center-embedding and right-branching. Based on processing models grounded in the accessibility hierarchy (Keenan & Comrie, 1972) and the phrase-structural distance hypothesis (O'Grady, 1997), it needs to be mentioned that to study the mechanisms of comprehension in understanding relative clauses, there needs to be certain self-paced

reading tasks as well as eye-tracking ones to determine the above-mentioned factors (embeddedness and focus). Accordingly, center-embedding refers to the kind of relative clause that is situated at the subject position of a given sentence, while the subject of the matrix clause functions as our head noun. For example, 'A school boy that ~~he~~ enjoyed spending time with a classmate ran to his mom and hugged him'.

On the other hand, right-branching refers to relative clauses that are known to be of object position i.e. their head noun is actually the object of the given sentence. For example: 'The mom ran to a school boy that a classmate enjoyed spending time with ~~him~~ and hugged him'.

An overview of the research done shows that center-embedding relatives are easier to process when they are compared to right-branching ones. Provided that the focus (head noun) functions as the subject of the relative clause, the clause is technically called a subject-extraction relative clause that is abbreviated as SRC. Likewise, a relative clause with a head noun serving the function of its object is named an object-extraction relative clause (ORC). The following example clarifies the point:

1. The guy that argued with his brother talked to his friend and killed him.
2. The guy that his brother argued with talked to his friend and killed him.
3. The friend talked to the guy that argued with his brother and killed him.
4. The friend talked to the guy that his brother argued with and killed him.

Looking at the examples, from 1 to 4, we can see the fact that they are, respectively, center-embedding SRC, center-embedding ORC, right-branching SRC and right-branching ORC. Accordingly, these kinds of differences in the structure of relative clauses can result in a number of problems in the processing preference employed by the reader or listener. As an example, the reader might face ambiguity in the interpretation of a given sentence in which an object relative clause is used to modify the subject of a sentence. In this example, whether it was the brother who killed him or the friend, or even who 'him' actually is.

One other basic element investigated in this study is the canonical word order and its variation in the surface structures of different sentences. An important issue in the study of language is actually the difference between the 'underlying' word order (Subject-Verb-Object) and the various surface ones appearing in any pieces of text in a language (Love & Swinney, 1998). Basically, variations of word orders across different languages influence the access of the relativized gaps depending on which structural position a gap is located in the sentence. A central question in the study of language is the distinction made between the underlying word order (e.g. Subject-Verb-Object), also called canonical order, of a given language and various surface structures of these elements. Generally, it is accepted that some languages have dissimilar canonical orders. Some languages are strongly ordered in terms of canonical word order, and others are not.

1.3 Purpose of the Study

The researchers in this study aim to investigate the processing mechanism, being embeddedness, focus and canonical word order, of English relative clauses by Iranian learners of English. This research has been done and has investigated the mechanisms among native speakers. This study, in essence, is actually an expansion of the above-mentioned previous studies done on sentence processing preference in English SRC and ORC for L2 learners. To be more specific, it is worth mentioning that this paper

will offer valuable guidance for Iranian English learners and teachers in learning and teaching the English SRC and ORC relative clauses.

1.4   Research Questions

Based on the purpose of the study, the following research questions are formed to be addressed in this study:
(1) Is there a difference between the time it takes (latency) for Iranian learners of English to comprehend Object relative clauses defining the object/subject of a noun and Subject ones defining the object/subject of a noun?
(2) Is there a difference between the accuracy of understanding English to comprehend Object relative clauses defining the object/subject of a noun and Subject ones defining the object/subject of a noun by Iranian learners of English?
(3) What does this difference/similarity suggest about the nature of the processing mechanisms of relative clauses?

2.   LITERATURE REVIEW

According to Sheldon (1974), who worked on a corpus of journal articles, relative clauses are of various natures in different genres, which leads to different effects on readers. Chang (2008) reports the use of full and reduced relative clauses and their emphasis shifts. Gibson (1998) makes a comparison between different types of relative clauses used in a specific kind of genre which demonstrated the relationship between the use of relative clauses and the stylistic techniques employed by the authors.

Furthermore, frequencies of different types of relative clauses have been studied in a number of research articles in which it was claimed that subject relative clauses are used more than object relative clauses (Traxler et al., 2002). Relative clauses have been extensively scrutinized from various angles. The investigation of relative clauses based on corpus studies has proved to be a very much fruitful area of research. Chang (2008) categorizes the research on relative clauses into three main groups. Accordingly, the first type of research investigates the universals of language in dealing with information within relative clauses, the second looks into the instructional impacts on relative clause acquisition, and the third one examines 'the cross-linguistic influences' on language learners' acquisition of relative clauses. Knowing that they can be an important source of errors in different aspects of language use, it is worth mentioning that studies on mistakes made by EFL students are still lacking. Furthermore, little attention has been given to this in the context of Iranian EFL students.

According to what was said in the review above, it is seen that subject preference is actually accepted in the English language and supported by a large number of researches works and theories, while this matter has not been investigated yet about learners as much. Most studies have worked on the native speakers; however, a few research studies on the acquisition of relative clauses by second language learners have been concluded as well. For instance, Gass (1980), Doughty (1991) and Hamilton (1994) have, in separate studies, demonstrated the acquisition of subject relative clauses in English as a second language, in which subject relatives are more easily

produced and comprehended than object relatives. Likewise, Sakamoto and Kubota (2000) also demonstrate the prominence of subject preference in the acquisition process of Japanese relative clauses by English participants. In the year 2007, Kanno (2007) conducted another study on the factors influencing the processing of Japanese relative clauses used by second language learners. On the other hand, the matter of subject preference is not actually applicable when it comes to all L2 learners. Accordingly, Yip and Matthews (2007) carrying out a study on relative clauses in Cantonese-English bilingual children concluded that object relatives were, in fact, produced before subject ones. As one can see, this is a challenge to the language universals. That is, in spite of all the research done on this subject, there actually is a scarcity of research, to the best knowledge of the researcher, about the processing mechanism of English relative clauses used by Iranian learners of English. Therefore, in the present study, the researcher used some Iranian upper-intermediate and advanced English learners with the aim of knowing whether English subject preference is also applicable to the Iranian English learners and also investigated possible causes.

3. METHODS

3.1 Participants

Thirty students studying the English Literature at Ferdowsi University of Mashhad, Iran, were randomly chosen to participate in the experiment, all of whom were from the same batch of the entries of 2016. All of them were senior English Literature students aged between 19 and 24. They are all native speakers of the Farsi language. Gender was not a focus in the study, though 21 students participating in the study were female students, and the other nine were male students.

3.2 Materials

The present study used a 2×2 factorial design. Accordingly, 24 sets of sentences were constructed, each of which was formed in four different conditions, as mentioned in the theoretical background of the study, i.e. the subject-modifying subject relatives (S-SR), the subject-modifying object relatives (S-OR), the object-modifying subject relatives (O-SR) and the object-modifying object relatives (O-OR). To eliminate any possible confusion caused by other interfering factors, all of the noun phrases used the target sentences were chosen to be animate. Here is one example:
1. The guy that argued with his brother talked to his friend and killed him.
2. The guy that his brother argued with talked to his friend and killed him.
3. The friend talked to the guy that argued with his brother and killed him.
4. The friend talked to the guy that his brother argued with and killed him.

Along with the 24 sets of target stimulus, 40 fillers of various types were added into the experiment so as for the participants not to be able to find out what we were trying to test and form a thinking pattern based on their answers to the questions. Furthermore, naturally, all these sentences were written and displayed in standard English. A complete list of the used 24 sets of sentences is available in the Appendix of the current paper.

3.3   Procedures

3.3.1 Procedures of data collection

The researchers employed a self-paced reading experiment, using a moving window display. To do so, we ran the experiment using Doug Rohde's Linger software, which is a widely used software in self-paced. All the experiment was held on the researchers' laptop. Before beginning the experiment, the participants were told to read some instructions. As well as this, a number of practice sentences and questions were shown to inform them about the format of the presented questions. After assuring that no problem was left, our participants were left undisturbed to do the experiment themselves.

In each trial, the participants were presented with a series of hyphens showing the length and position of words in the given sentences. The participants were to press the spacebar to view each word. Each time the spacebar was pressed, a new word showed up on the screen and the previous one disappeared, this was done to the point that the whole given sentence was read by the participants. The time between these two presses was measured by the software as the reading time of the word. After the completion of each sentence, a relevant yes or no comprehension question concerning the preceding sentence showed up. Afterwards, the participants were asked to press F key on the computer keyboard for —yes, or J key for —no. As an incorrect answer was recognized, the participants were shown with —Oops, the wrong answer on the screen. However, no response was shown providing the answer was correct. The participants were to read the sentences at a natural speed and made sure that they were cautious enough to comprehend the meaning of the sentence. After the completion of the tasks, the researchers gathered the response-time data and saved them for later SPSS analysis.

3.3.2 Procedure of data analysis

Having gathered the required data using a self-paced reading instrument, we acquired two important pieces of information, namely the accuracy of responses and the response times of each participant. The data were, subsequently, put into analysis using SPSS software. As for the accuracy, simply the accurate answers were put against the inaccurate - wrong - answers for each item, and the frequency of each was concluded with a percentage showing its relevant difficulty for the participants, who were advanced learners of English. Afterwards, as the purpose of the study, the response time of each sentence presented in the experiment - latency - which is a significant factor in the experiment, was calculated in six positions in the sentences; it was then tabulated. Using the SPSS program version 25, the mean and standard deviation of each position was calculated for further analysis. Having measured and listed the response time of each position, the researchers made a comparison between subject relatives and object relatives employing Oneway ANOVA.

4. RESULTS AND FINDINGS

4.1 Accuracy

All the question response accuracies for each condition were collected by using the SPSS software, that is, as seen in Table 1, the percentage of correct comprehension questions is ordered.

Table 1. Accuracies of comprehension questions.

Subject –Subject Modifying Relative Clauses	Subject-Object Modifying Relative Clauses	Object-Subject Modifying Relative Clauses	Object-Object Modifying Relative Clauses
69.17%	65.34%	60.34%	49.91%

Comparing the data in the table, it can be easily found out that the correctness percentage of subject relative, similar to the previous research studies on other languages learners of other nationalities such as Chinese and Spanish language learners, is signifcantly higher than that of object ones, regardless of the fact that they are subject modifying or object modifying. In addition to this, it can be seen that the accuracy of subject modifying relatives is higher than that of the object modifying ones. Interestingly, this is in accordance with the results concluded from previous studies conducted on native English speakers.

4.2 Latency (Response time)

The concept of latency is a significant factor that is to be considered in this experiment. The researchers mainly concentrated on the response time of six positions in the sentences, beginning from the head noun of the relative clause. The time spent on each position and the standard deviations are shown in Table 2.

Table 2. Response times (in millisecond) plus their standard deviations.

S-SR	The Mean	The Std.	Head Noun Mean	Head Noun Std.	That Mean	That Std.	P1 Mean	P1 Std.	P2 Mean	P2 Std.	P3 Mean	P3 Std.
S-OR	441	151	672	459	538	318	828	540	504	354	808	589
O-SR	450	151	691	648	554	341	470	254	857	730	847	516
O-OR	473	257	668	415	577	423	741	379	535	281	801	524
	469	304	702	492	602	379	531	401	818	625	819	549

Having measured and listed the response time of each position, the researchers made a comparison between subject relatives and object relatives employing Oneway ANOVA. Initially, the concepts and data belonging to S-SRs and the S-ORs were studied. Drawing on the results, it was demonstrated that when the participants read the word 'the', $F(1) = 0.638$, $p > 0.05$, the difference occurred was actually insignificant. When the participants reached the head noun, $F(1) = 0.164$, $p > 0.05$, the difference which occurred was not significant. The same thing occurred at the next position 'that', $F(1) = 0.208$, $p > 0.05$. Afterwards, the following position was studied 'P1'; it was illustrated that $F(1) = 62.133$, $p < 0.05$, the existing difference was actually significant. As well as this, the next position 'P2' demonstrated a significant difference, with $F(1) = 35.471$, $p < 0.05$. Additionally, at the last position 'P3', $F(1) = 0.368$, $p > 0.05$, the

occurring difference was insignificant. Using the same method, the researcher studied the O-SRs and the O-ORs as well. The results were again quite alike. When it came to the position of 'the', $F(1) = 0.037$, $p > 0.05$, the difference was not of significance. Next, at the position of head noun, $F(1) = 0.583$, $p > 0.05$, the existing difference was not significant either. The same thing took place in the following position 'that', with $F(1) = 0.265$, $p > 0.05$. Significant differences began at the next two positions, namely 'P1' and 'P2', demonstrating the following data $F(1) = 28.491$, $p < 0.05$ and $F(1) = 31.829$, $p < 0.05$. At the last position P3, $F(1) = 0.016$, $p > 0.05$, which shows that the difference was not significant either.

5. DISCUSSION

It was clearly mentioned at the beginning of the paper that English subject preference is supported by many experiments done on native speakers of English. In this study, we concluded that the same tendency exists among Iranian learners of English as well. As shown in the result section, the subject preference is also applicable to Iranian learners at both levels of accuracy of comprehension questions and response time of relative clauses. To explore the possible reasons for this phenomenon and its seeming universality, different well-established theories are presented by the researchers that can explain the results of this research. As a matter of fact, the results of the current study which was conducted in the EFL context among Iranian students of English at advanced levels are justifiable based on frequency-based theories, role shifting based theories, distance-based theories, and universality-based theories.

Gibson (1998) worked on a theory of the relationship between the sentence processing mechanism and the available computational resources, called the Syntactic Prediction Locality Theory. There are two components included in this theory; one is the integration cost component, and the other is the memory cost related to keeping track of the non-optional syntactic requirements component. As said by Gibson (1998), both the integration cost and the memory cost are heavily affected by locality, which is to say, the longer the distance between an incoming word and the head word is, the greater the integration cost; and the longer a predicted category needs to be kept in the short-term memory, thus the greater the memory cost. Thus, it can be said that a longer filler-gap distance of object relatives results in a higher memory cost with more predicted syntactic categories in memory plus a higher level of integration cost with longer distance of attachment. This is actually a distance-based theory which can easily explain the existing subject preference among Iranian learners of English. It can be said that two noun phrases of the same type in one sentence can influence the reader's comprehension process. For instance, let us look at the examples which were actually taken from the questions given to the participants.

1. The guy that argued with his brother talked to his friend and killed him.
2. The guy that his brother argued with talked to his friend and killed him.
3. The friend talked to the guy that argued with his brother and killed him.
4. The friend talked to the guy that his brother argued with and killed him.

Considering these examples, in sentence (3), 'his brother' and 'him' are from the same group. We can obviously see that the distance between the two words is short, relative to the number of words in the sentence. However, in sentence (4), we can see the distance between the two words 'guy' and 'him' is 7 words, which is comparatively

very long. This leads to a higher number of mistakes when it comes to understanding the relative clause as well as processing the sentence.

As it is known, some of the theories about the English subject preference are actually based on a number of universal features of the language. It is assumed that the universality of language is also held responsible for the language choice preferences to some extent. The concept of Canonical Word Order is a theory, discussed by MacDonald and Christiansen (2002), which is relevant to the results acquired by the researchers of this paper. From their point of view, since the basic word order in English is S-V-O, a relative clause with the same order is easier for the reader to understand. For example, in example (3), the word order of subject relatives is S-V-O ('The friend talked to the guy'), which is actually parallel with the canonical English word order, and also the first part is also similar to the existing word order in Farsi (S-V). On the other hand, this order turns to be that of O-S-V in the object relatives ('the guy that his brother argued with'). The change of the word order makes it more time consuming, as it is shown in the time delay investigation, in the sentence comprehension process.

If we are to explain the subject preference among Iranian learners of English in terms of role-shifting based theories, scholars (Friedmann & Novogrodsky, 2004) have noticed that certain shift can happen to the role of the head noun in an object relative. It should be mentioned in the Parallel Function Account which was established by Sheldon (1974). He argued that the shifting of the role of the head noun in an object relative makes it harder to process and understand. For instance, in the above example (3), the head noun 'friend' acts as the subject of the matrix clause in all of the mentioned sentences.

One other possibility, the first one which appealed to the researchers by a review of the related literature, justifying subject preference among learners of English language, is known to be the high frequency of subject relatives when we compare them with object relatives. Researchers, having checked in language corpus, found that subject relatives are much more frequently used than object relatives. Therefore, it is argued that subject relatives are actually easier for participants to process since they are comparatively more familiar with this kind of relative clauses. The researchers of this paper are well convinced that the more one reads and encounters with subject relatives, the easier they find it to process. Now, it can be clearly said that the frequency-based theory is applicable to Iranian learners of English.

6.   CONCLUSION

Having conducted a self-paced reading experiment using Linger software and then analyzing the acquired data by SPSS, the researchers of this paper have come to the conclusion that, quite like English native speakers, English subject preference is also applicable to Iranian learners of English. The acquired results illustrated that the learners would spend significantly less time processing English subject relative clauses when compared with object relative clauses. In order to investigate the reasons for which English subject preference found among Iranian learners of English, in the discussion section, we have reviewed some theories which were raised by previous researchers and were relevant to the results of this study, such as embeddedness, canonical word order and processing mechanisms of relative clause. Having drawn an

analogy between the structure of sentences in Farsi and English, the researchers came to the conclusion that the higher frequency of subject relative clauses, the universality of canonical word order, parallel functioning as well as integration and memory cost can be possible explanations of the phenomenon observed in this study. Another noteworthy point found by the researchers was the fact that subject relatives showed to be processed faster than object relatives. The results of this study can contribute to the establishment of universal structures found in languages all over the world. As well as this, the results can be used in language material development and designing programs in which grading the material in terms of difficulty is of importance.

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APPENDIX

Number of item out of 64	The 24 experimental sentences employed in the software Linger so as to be shown to and answered by the participants of this study. Besides, 40 sentences were used as fillers in the study.
50	The guy that argued with his brother talked to his friend and killed him.
8	The guy that his brother argued with talked to his friend and killed him.
52	The friend talked to the guy that argued with his brother and killed him.
26	The friend talked to the guy that his brother argued with and killed him.
25	A taxi driver that sold a car to his father saw a boy and walked with him
17	A taxi driver that his father sold a car to saw a boy and walked with him.
43	A boy saw a taxi driver that sold a car to his father and walked with him.
51	A boy saw a taxi driver that his father sold his car to and walked with him.
18	The man that agree with his boss agreed with his friend and laughed at him.
4	The man that his boss agreed with agreed with his friend and laughed at him.
22	His friend agreed with the man that his boss agreed with and laughed at him.
48	His friend agreed with the man that his boss agreed with and laughed at him.
64	The child that played with the babysitter ran to his father and hugged him.
21	The child that the babysitter played with ran to his father and hugged him.
28	The father ran to the child that played with the babysitter and hugged him.
33	The father ran to the child that the babysitter played with and hugged him.
29	A school boy that enjoyed spending time with a classmate ran to his mom and hugged him.
50	A school boy that his classmate enjoyed spending time with ran to his mom and hugged him.
25	The mom ran to a school boy that enjoyed spending time with his classmate and hugged him.
13	The mom ran to a school boy that a classmate enjoyed spending time with and hugged him.
3	A nice teacher that shouted at the student ran to a colleague and smiled at him.
62	A nice teacher that the student shouted at ran to a colleague and smiled at him.
35	A colleague ran to a nice teacher that shouted at the student and smiled at him.
10	A colleague ran to a nice teacher that the student shouted at and smiled at him.