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## ABSTRACT

This paper describes our initial empirical efforts towards extracting, analyzing and annotating the most frequent discourse connectives in Modern Standard Arabic (MSA). We based our study on The Arabic Treebank corpus as a large tagged MSA corpus. We extracted the most frequent discourse connectives, and listed all possible discourse relations they might convey. We discuss issues of ambiguity in defining Arabic discourse connectives and their associated discourse relations. This empirical analysis will be used in future for developing algorithms for the automatic identification of discourse connectives, the text segments they relate and the discourse relations they convey.

Keywords: Arabic discourse structure, discourse connectives, cohesive ties, discourse relations, Arabic NLP

## 1. Introduction

The Arabic computational linguistic community obviously focused on research on the morphological and syntactic structure of Arabic, but there are almost no about extensive studies of discourse structure. However it is agreed that a text is not just a random sequence of sentences, but a coherent object where different text segments (clauses, sentences or sequences of sentences) are related via so-called discourse relations.

(1) *John didn't go to the party. He was tired.*

Thus, in Example 1 the second sentence gives a potential reason for the event in the first sentence --- a CAUSAL relation between the two sentences holds. Other typical relations are CONTRAST, CONDITION or TEMPORAL relations. In examples such as (1) these relations have to be inferred, i.e. are only present *implicitly*, but often they are signaled explicitly via so-called discourse connectives such as *because*, *instead*, *if* and *after*. Thus, in Example 2 the connective *because* in the second clause establishes explicitly that the reason for John being absent from the party is that he was tired (CAUSAL relation), whereas the connective *instead* in the third clause contrasts going to bed with going to the party (CONTRAST Relation). The connective *because* in Example 2 therefore takes clause 1 and clause 2 as its arguments whereas *instead* takes clause 1 and clause 3 as its arguments. This means discourse relations can hold between non-adjacent clauses.

(2) *John didn't go to the party, because he was tired. Instead, he went to bed.*

Discourse connectives are widely studied in theoretical linguistics, and offer a wide range of applications in computational linguistics. For example, in automatic text generation, it is necessary to use the right connectives in the right places in the generated text (Hovy 1993). Moreover, for text summarization, text segments offering mainly elaboration of related text segments might be ignored (Marcu 2000). Although discourse connectives have been intensively studied for English, there is no reliable list of discourse connectives and associated relations for Arabic can be used as a basis of advanced studies of discourse structure.

This paper describes our initial empirical efforts towards extracting, analyzing and annotating the most frequent discourse connectives in Modern Standard Arabic (MSA). We base our study on the Penn Arabic Treebank (Maamouri, Bies et al. 2004) as a large tagged MSA corpus. Our bank of analyzed discourse

connectives and their features will help researchers improve computational applications of Arabic by expanding from sentence level to discourse level.

The remainder of this paper is organized as follows: Section 2 describes related work. Section 3 describes our methodology for collecting the most frequent discourse connectives in MSA, and discusses the different grammatical categories of connectives. Several instances of ambiguity in defining connectives or relations will also be illustrated in that Section. We discuss arguments of discourse connectives and compare our analysis to analyses of English discourse connectives in Section 4. We conclude with observations about advantages and shortcomings of our approach and considerations for future work.

## 2. Related Work

Discourse connectives have two distinct functions as distinguished by Cohen (Cohen 1984): (i) enabling faster recognition of discourse relations by the reader (the hearer) and (ii) allowing the recognition of discourse relations which could not be inferred in the absence of the connectives. We follow (Miltsakaki, Prasad et al. 2006) in that we define discourse connectives as *lexical expressions that relate two text segments that express abstract entities such as events, belief, facts or propositions*. These text segments are called the *arguments* of the discourse connective. Discourse connectives in English are drawn almost exclusively from the parts of speech of coordinating or subordinating conjunctions (*and, but, or*), adverbials (*then, later, otherwise*), and prepositional phrases (*in contrast, as a result*). In this study, we do not discuss discourse relations between segments that are not explicitly signalled by a connective, i.e. we concentrate on cases such as Example 2 and ignore cases such as Example 1.

Discourse connectives were studied both theoretically and empirically ever since the function of discourse connectives has been recognized. On the one hand, theoretical research concentrates on coherence relations between text segments and culminates in the derivation of either linear sequences of such relations such as in Halliday & Hassan's representation of text (Halliday and Hassan 1976) or of a hierarchical tree structure such as in Intentional Discourse Model (Grosz and Sidner 1986), Linguistic Discourse Model (LDM) (Polanyi 1998) and Rhetorical Structure Theory (RST) (Mann and Thompson 1987). These theories are all aware that discourse connectives can signal such relations but they do not concentrate on establishing a comprehensive list of connectives and their features.

On the other hand, the empirical study of discourse (concentrating on English) has provided us with lists of discourse connectives, the relations they convey and their usage by *analysing corpora*, such as the Penn Treebank or the Brown corpus. For example, Marcu (Marcu, Amorrortu et al. 1999; Marcu 2000) used the Brown corpus<sup>1</sup> to extract a list of connectives and their attributes for English and to automatically construct RST-Tree text representations. Other recent empirical efforts have resulted in large-scale annotation of discourse connectives in English within the Penn Discourse Treebank Project for English (Prasad, Dinesh et al. 2008), with follow-on projects for Chinese (Xue 2005) and Hindi (Husain, Agrawal et al. 2005), for example. These efforts are relatively theory-neutral and are therefore an ideal testable for discourse theories as well as excellent training and test sets for automatic applications. We therefore mainly follow their methodology in developing a discourse treebank for Arabic, although some language-specific adjustments must be necessary.

While discourse connectives have been studied extensively for English and other languages, there is, to the best of our knowledge, hardly any theoretical or empirical work on Arabic connectives or discourse relations. Al-Sanie et al (Al-Sanie, Touri et al. 2005) and Seif et al. (Seif, Mathkour et al. 2005) discussed a limited set of rhetorical relations and discourse connectives. However, both did not distinguish between discourse connectives such as (*بسبب* , *because*) and other syntactic connectors such as prepositions (*في* *in*) or (*مع* , *with*) where the latter signal a semantic relation between two concrete objects instead of a discourse relation between abstract entities in clauses or sentences<sup>2</sup>. Moreover, the studies had a small empirical basis using only a limited number of Arabic texts. Therefore, there is no list of discourse connectives for Arabic available, which can be considered more exhaustive, nor does a corpus exist where these connectives are annotated in context with regard to their discourse relations or arguments.

## 3. Arabic Discourse Connectives

### 3.1. Collection of Discourse Connectives

We have collected our list of discourse connective in three stages.

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<sup>1</sup> The Brown corpus consists of 500 texts, each consisting of just over 2,000 words. The texts were sampled from 15 different text categories. [http://www.essex.ac.uk/linguistics/clmt/w3c/corpus\\_ling/content/corpora/list/private/brown/brown.html](http://www.essex.ac.uk/linguistics/clmt/w3c/corpus_ling/content/corpora/list/private/brown/brown.html)

<sup>2</sup> Some discourse studies in English also study both these types of connectors, i.e. (Marcu, Amorrortu et al. 1999; Marcu 2000)

**Stage 1:** We analyzed 50 texts in the Penn Arabic Treebank corpus (APTb) and extracted all discourse connectives they contain. In order to collect a large set of discourse connectives of MSA, an additional six texts were analyzed from Arabic resources in the Internet. They were from different genres such as education, politics and social affairs. Moreover, using our linguistic knowledge, we include so-called *modified form* connectives in our list. These modified form connectives share the basic form and function with a different connective but have an additional suffix, proclitic, enclitic or tokens. For example, the connective ‘لو’ has a set of modified forms ‘لولا’، ‘لو أن’ and ‘حتى لو’. All these connectives indicate the same discourse relation ‘CONDITION’. An example in English would be the modified form *even if* of the connective *if*, which indicate the same discourse relation but vary in strength.

**Stage 2:** We extracted all possible POS tags and Buckwalter transliteration forms for all connectives in the list. Using the Buckwalter forms we automatically generated a list of all instances of occurrence in the APTb for each connective. In addition, using POS tags we examined other tokens having the same POS tag (e.g. CONJ) as to whether they are discourse connectives. At the end of this stage we had a list of connectives as well as a list of all instances of each connective in our list and its frequency of occurrence.

**Stage3:** We verified a random set of instances of each connective and extracted all surface-based features we needed: the connective’s position, type and syntactic category in addition to discourse relations it signals. In parallel, we also recorded variety cases of ambiguity (see Section 3.4).

This process resulted in a list of the 70 most frequent discourse connectives in MSA, plus 98 modified forms of them, yielding 168 discourse connectives overall with 15 discourse relations. A subset of them is shown in appended table, appendix A.

## 3.2 Types of Discourse Connectives

Discourse connectives do not fall into a unique syntactic category. There are three main syntactic categories of discourse connectives in MSA: (i) coordinate conjunctions (ii) subordinate conjunctions (iii) adverbs & prepositional phrases and (iv) prepositions.

### 3.2.1 Coordinating Conjunctions

Two dependent clauses or sentences can be joined by a coordinate conjunction such as (‘لكن’ *but*), (‘أو’ *or*) or (‘و’ *and*). These conjunctions indicate discourse relations such as CONTRAST, ALTERNATIVE and JOINT (see Example 3 and 4).

All Arabic examples are given a close-to-source translation to be read from right to left and indicated between square brackets as well as a freer standard English translation (to be read from left to right).

- (3) تستطيع ان تذهب الى المنزل الآن أو تنتظرنى لساعة واحدة (4) السيارة متطورة جدا . لكنها باهضة الثمن  
 [ cost high **but-it-is**. very modern the-car ] [one for-hour wait-me **or** now home go you-can]  
 {The car is very modern. **But** it is too expensive.} {You can go home now **or** wait for me one hour}

### 3.2.2 Subordinating Conjunctions

Subordinate conjunctions introduce independent clauses that are syntactically dependent on the main clause. In Arabic there are two kinds of subordinate conjunctions (similar to English, Chinese and Turkish): **Simple subordinate conjunctions:** the subordinate clause is introduced by a subordinate conjunction such as (‘لأن’ *because*) as in Example 6 - CAUSAL relation, (‘بينما’ *while*) – CONTRAST relation and (‘حيث’ *since*) – ELABORATION relation.

- (6) تم رفض الخطة المقترحة للمشروع لأنها غير مستوفية للشروط المتفق عليها  
 [on agreed of-conditions compliant non **because-it-is** of-the-project the-proposed the-plan denied]  
 {The proposed plan of the project has been denied **because** it is non-compliant with the agreed terms.}

**Paired subordinate conjunctions:** Paired subordinate conjunctions consist of two non-adjacent lexical items: the first introduces the subordinate clause Arg2 and the other the main clause Arg1. They are frequent in MSA. In Example 7 and 8, the paired connectives (‘ورغم أن’ *although/despite*), and (‘إذا..ف’ *if...then*) indicate the discourse relations CONTRAST and CONDITON respectively. Note that they can be translated with simple connectives in English in the examples.

- (7) ورغم ان الطائرات كانت تحلق باستمرار  
in-continuous flying were planes although and  
في سماء المدينة ، فإن الحياة المدنية لم تتأثر  
[affected not civilian the life **then**, city sky in  
{**Although** the planes were flying continuously  
in the city sky, civilian life was not affected}
- (8) اذا كان الجو صحواً ، فالنلعب في الحديقة  
[the garden in let-us-play, clear atmosphere **If**]  
{**If** the weather is fine, let's play in the garden}

### 3.2.3 Adverbs & prepositional phrases

Any sentence-modifying adverbs or prepositional phrases which *express discourse relations between two abstract entities* are considered as discourse connectives. For example, the connectives ('لذلك' *therefore*), and ('بالتالي' *consequently*) indicate a RESULT relation while ('طالما' *because/ so long as*) and ('نتيجة لـ' *as a result of*) indicate a CAUSAL relation. Adverbs also can be simple or paired, for example, ('طالما...فـ' *As-long-as*) is a paired adverbial connective in Example 9. Adverbial connectives usually introduce Arg2.

- (9) طالما ان المؤتمر لم يحقق اهدافه فلن نجد من يثق بنتائج لاحقا  
[later its-findings trust who find will-not its-objectives achieve not the-conference that so-long-as]  
{**As long as** the conference has not achieved its objectives, nobody will trust its findings late}

### 3.3.3 Prepositions

There is a set of prepositions in Arabic that can relate abstract entities and indicate discourse relations between them. For example, the preposition ('لـ' due to) and ('إلا' except) are followed normally by nominalizations (nouns derived from verb).

## 3.3 Ambiguity Issues

Several issues of ambiguity and complexity were occurred when identifying discourse connectives and their relations. First, due to the complexity of Arabic morphology, connectives do not have to correspond to a separate word token or sequence of word tokens in MSA. Although this can be the case such as for stand-alone-token connective 'بلـ' (*but*), the connective can also occur as a prefix (e.g.. 'فـ' *so/ then*), an enclitic (e.g 'لكنه' *however*, 'بعدها' *after*) or a proclitic (e.g. 'بـ' *since*). Stemming is needed as preprocessing for any successful discourse annotation for Arabic.

Secondly, the frequent absence of the use of diacritics also can have a negative effect on the automatic identification of discourse connectives. For example, the connectives 'إذا' (*if*) and 'إذّا' (*so*) are often written as 'اذا' without diacritics and Hamzah (ء). Moreover, the absence of the Hamzah in connectives such as 'إلا' leads to ambiguity whether 'إلا' is a connective ('إلا' *except*) or just a question word ('إلا'). We did tackle the majority of syntactic ambiguity issues when collecting discourse connectives from the Penn Arabic Treebank by using POS tags and Buckwalter forms.

However, using the POS tag alone as an indicator for discourse connectives can be insufficient. There can be discourse connectives which do not fall into the standard list of POS tags. For example the connective ('بعدها' *after*) is labeled by 'REL\_ADV' POS tag. It is rare to find other connectives marked as this POS tag. Moreover, some connectives have more than one POS tag such as the connective ('حيث' *since*) which was marked sometimes as CONJ and others as REL\_ADV in the treebank. In addition, some conjunctions but not discourse connectives are sometimes labeled by POS tags the same as of discourse connectives such as ('حسبما' *as*) is labeled with CONJ POS tag. The connective ('و' *and*) is always marked as 'CONJ' even when it relates two noun phrases, not abstract objects, such as ('كرة القدم و كرة السلة') football **and** basketball). Therefore, the frequency numbers in the appended table, which were automatically generated, are only approximate.

There is also a range of ambiguity issues in assigning discourse relations. One connective in MSA can indicate more than one discourse relation such as ('بينما' *whereas/while*), which can express a TEMPORAL relation as in Example 10 and a CONTRAST relation as in Example 11.

- (10) لقي 11 شخصا مصرعهم عند انفجار انبوب نفط في جنوب نيجيريا بينما كانوا يشفطون النفط منه بطريقة غير قانونية  
[legal non by-method from-it the-oil drawing were **while** Nigeria south in petrol tube explosion  
when their-death people 18 faced]  
{18 people were killed when an oil pipeline exploded in southern Nigeria **while** they were illegally drawing oil}

- (11) نجح مهرجان التسوق لهذا العام في تحقيق اعلى مستوى من الإيرادات، بينما توقع له مراقبون الفشل  
 expected **while**, profits from level higher achieving in year for-this the-shopping festival succeeded]  
 [the-failure observers for-it  
 {The shopping festival has succeeded this year in achieving a higher level of profits, **while**  
 observers expected it to be a failure.}

In addition, some connectives express two relations at the same time. Thus in Example 12, the connective ('بعد' *after*) indicates mainly a TEMPORAL relation. However, the connective pragmatically expresses a CAUSALITY relation.

- (12) بعد رحيلي عن القرية، لم اشعر بالسعادة مجدداً  
 again in-happiness feel not, village from I-leave **after**  
 {**After** I left home village, I never was happy again}

#### 4. Comparison with English

Arabic is a semi-free word order language. This characteristic obviously affects the argument structure of discourse connectives. In Arabic, discourse connectives and their arguments follow different canonical forms. The two main canonical forms for simple connectives are <Arg1+DC+Arg2> and <DC+Arg2, Arg1 >. While there is only one possible canonical form for paired connectives <DCP1+Arg2+ DCP2+Arg1>. DC stands for discourse connective, DCP1 and DCP2 stand respectively for the first and second parts of paired connective.

We compare our study to existing studies in English and discuss several differences between discourse connectives in Arabic and in English. We cover a similar range of connectives as a recent study for English (Prasad, Dinesh et al. 2008). They annotated over 1 million words in the Penn Treebank, covering 100 distinct explicit connectives. They also annotated 18459 connectives in tokens which is our next step.

Some Arabic discourse connectives do not have exact English equivalent connectives. For example, the equivalent English connectives of some Arabic paired connectives are not paired anymore. In Example 15, the paired connective (و لو أن... إلا أن...) translated to (*although*) a simple connective in English.

There can be several Arabic connectives that express the same discourse relation but that differ in relation strength. These connectives are often expressed by one single connective in English. For example, connectives ('لكن' however), ('بل' but), ('ذلك مع' however) and ('إلا أن' however) indicate in general a relation CONTRAST. However, the level of strength of CONTRAST for these Arabic connectives differs as shown in Table 1 and examples 15, 16, 17 and 18.

- (15) و لو أن جميع الأطفال استمتعوا بالرحلة إلا أنهم كانوا متعبين  
 [tired were they but in-trip enjoyed children all if-  
 and]  
 {**Although** all children enjoyed the trip, they were tired}

- (16) قدمت شركة البتروكيميايات العربية عرضاً مغرباً  
 great offer Arabic petrochemical company provide]  
 لتدوير الورق، لكن وزارة البلدية رفضته  
 [reject-it municipal ministry, but paper for-recycling  
 {The Arabic Petrochemical Company made a great offer for paper recycling. **However**, the Municipal Ministry turned it down}

- (17) نصحه الطبيب أن يقلع عن التدخين. و مع ذلك استمر بالتدخين أكثر مما سبق  
 with and .the-smoking of cease the-doctor advised]  
 ذلك استمر بالتدخين أكثر مما سبق  
 [previous than more in-smoking continued that  
 {The doctor advised him to cease smoking. **However**, he continued smoking more than before}

- (18) ان قضية فلسطين ليست قضية اقليمية او وطنية  
 national or regional issue not Palestine issue]  
 بل مسألة تهتم العالم الاسلامي اجمع  
 [all Islamic the-world concern problem but  
 {The Palestine problem is not only a regional or national problem **but rather** a matter of concern to the entire Islamic world}

The strong contrast in Arabic is often expressed solely via the discourse connective whereas in English you have to add other adverbs such as *only* and *rather* to express such a strong contrast in Example 18. In addition, two discourse relations with a subtle difference, which are expressed using a single connective in English, are expressed using different connectives in Arabic. For example, the connective *if* indicates different subcategories of the relation CONDITION (Prasad, Dinesh et al. 2008), namely Condition\_Unreal\_Past, Condition\_Factual\_Past, Condition\_Unreal\_Present, Condition\_Factual\_Pre-sent and Condition\_General. However, there is more than one connective indicating these relations in Arabic as presented in Table 2.

**Table 1. Different strength levels of relation Contrast indicated by some discourse connectives**

Arabic connectives	Strength level of rel. Contrast
بل	***
لكن - ولو أن... إلا أن... - مع أن... إلا أن...	**
مع ذلك - إلا أن	*

**Table 2. Several Arabic discourse connectives are equivalent to a connective *if* in English**

Condition Relations	Eng Conn.	Arabic Connectives
- General	if	في حال - اذا - ما دام
- Unreal_Past		لو
- Factual_Past		لو - في حال
- Unreal_Present		في حال - اذا - ما دام
- Factual_Present		في حال - اذا - ما دام

## 7. Conclusions and Future Research

The complex morphology, significant dialectal differences, semi-free word order and also a lack of language processing research and tools are the main reasons why Arabic remains a great challenge for the NLP community. We present the first larger-scale study for Arabic discourse connectives, resulting in a far more comprehensive list of Arabic connectives than previously existed. We also analyzed their properties using a range of real-life examples. However, this is only the first step towards our main target: development of algorithms for the automatic identification of discourse connectives, the text segments they relate and the discourse relations they convey. These algorithms should tackle all ambiguity issues we identified. They should also achieve good accuracy rates, comparable to the results for other languages. To generate training data for such algorithms, we plan as a next step discourse annotation for explicit connectives and their *arguments in context* following similar principles as the Penn Discourse Treebank Project for English. Therefore, we will generate an annotation manual for discourse connectives annotation in MSA. This manual will include a full description of explicit discourse connectives in MSA, associated discourse relations, and the selection of their arguments with clear examples. Intensive agreement studies will ensure reliability of the annotation.

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Appendix A

Table 3. Partial list of discourse connectives for MSA (overall 168 discourse connectives)

Connective Type	Connective	Approximately English Equivalent	Discourse Relations	Modified forms	Frequency Number In PATB
Simple	لكن	However/but	CONTRAST	و لكن - لكنه - لكنها - لكنهم - لكنهن	123
	لأن	Because	CAUSAL CONSEQUENCE EVIDENCE	و لأن - فلأن - لأن كان - لأن قد - لأنه قد	43
	بينما	While/ whereas	CONTRAST TEMPORAL	وبينما	25
	أو	Or	ALTERNATIVE RESTATEMENT	-	129
	لكي	In order to / for	CAUSAL EXPLANATION	كي - لكيلا	11
	لـ	To / in order to	CAUSAL	-	3073
	إثر	Because Right after	CAUSAL/ TEMPORAL	-	
	بفضل	Tanks to	FAVORABLE RESULT/CAUSE	-	0
	حين	When, at this time	TEMPORAL TEMPORAL/ CONTRAST	في حين - وحينها و حين - و في حين أثناء - في هذه الالتقاء	131
Simple/ Pair	إذا	If / whether	CONDITION	و إذا - فإذا - إذا...ف... - أما إذا... ف...	160
	لو	If ( for the past / future)	CONDITION	لو أن... لو... حتى لو لولا - لو... لو... لو... لما - لو... لو... قد... - لو... ف...	14
	بل	But/ instead	CONTRAST	بل كان - بل قد	18
	حتى	Until	TEMPORAL/ CONDITION TEMPORAL CONSEQUENCE	ما إن ... حتى ما كاد ... حتى ما ليث ... حتى حتى إن	155
	رغم	Although	CONTRAST EXPANTION	بالرغم من - رغم إن ورغم... ف- رغم إن ... إلا أن	40