

# Usability Evaluation of Lexicographic e-Services

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# Usability Evaluation of Lexicographic e-Services

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**Abstract**—Although the field of usability evaluation is a well-established discipline, there are no studies on how the usability of lexicographic e-services can be evaluated. This includes, for examples efficiency, effectiveness and user satisfaction when looking up for synonyms, meanings, or translations using online lexicons. In this paper, we propose to combine two types of usability evaluations to assess the usability of such services: a subjective user-experience evaluation and a more objective controlled experiment—demonstrating how both methods complement each other. We applied our proposed approach to evaluate two important online lexicographic e-services: a lexicographic search engine developed at Birzeit University (<https://ontology.birzeit.edu>) as well as Google Translate. The user-experience evaluation was conducted through a survey that involved 622 users, and was designed to measure effectiveness, efficiency, satisfaction and learnability. The controlled experiment involved a set of defined tasks, which were carried out by four teams (12 people) in two laboratories, and their performance was monitored. The tasks were designed to measure effectiveness and efficiency.

**Keywords**— *Lexicographic e-Services, Lexicographic Search Engine, Google Translate, Arabic Ontology, Usability Evaluation, User Experience Evaluation, Controlled Experiment.*

## I. INTRODUCTION AND MOTIVATION

Dictionaries are no more limited to the traditional use of

to lookup term translations does not yield good accuracy, especially in specialized and domain-specific translations.

A lexicographic search engine (<https://ontology.birzeit.edu>) was recently developed at Birzeit University [5], allowing people to search for translations, synonyms, definitions, among other lexicographic services – see Fig. 1. The search engine was developed with state-of-the-art design features and according to W3C recommendations and best practices for open data publishing, including the W3C Lemon model [6], which is particularly important for referencing and linking linguistic data. Furthermore, the search engine was built on top of the largest Arabic lexicographic database [2], which comprises about 150 Arabic multilingual lexicons that were manually digitized and then integrated into a normalized database model [7]. The database covers almost all domains, such as natural sciences, technology and engineering, health, economy, art, humanities, and philosophy, among others. It also includes many types of lexicons, such as modern and classical linguistic lexicons, thesauri, glossaries, lexicographic datasets, bi- and tri-lingual dictionaries, as well as the Arabic Ontology – an Arabic WordNet with ontologically cleaned content, used to reference and interlink lexical concepts [8, 9]. The database currently contains about 2.4M multilingual lexical entries, 1.1M lexical concepts, 1.5M translation pairs in Arabic, English and French, 0.7M classes, and 0.5M semantic relations.

Diana Alhafi, Anton Deik, Mustafa Jarrar: Usability Evaluation of Lexicographic e-Services. Proceedings of the 2019 IEEE/ACS 16th International Conference on Computer Systems and Applications (AICCSA). Pages(1--7), IEEE. Abu Dhabi, UAE. 2019.

<http://www.jarrar.info/publications/ADJ19.pdf>

- How to measure efficiency, effectiveness and user satisfaction when looking up for synonyms, meanings, or translations using online lexicons?
- Although the field of usability evaluation is a well-established discipline, there are no studies on how the usability of lexicographic e-services can be evaluated!

# Our approach

- Combine two types of usability evaluations to assess the usability of e-lexicographic services =  
**subjective** user-experience + **objective** controlled experiment
- We show how both methods complement each other.
- Experiments: evaluate two online lexicographic services: a lexicographic search engine developed at Birzeit University as well as Google Translate.

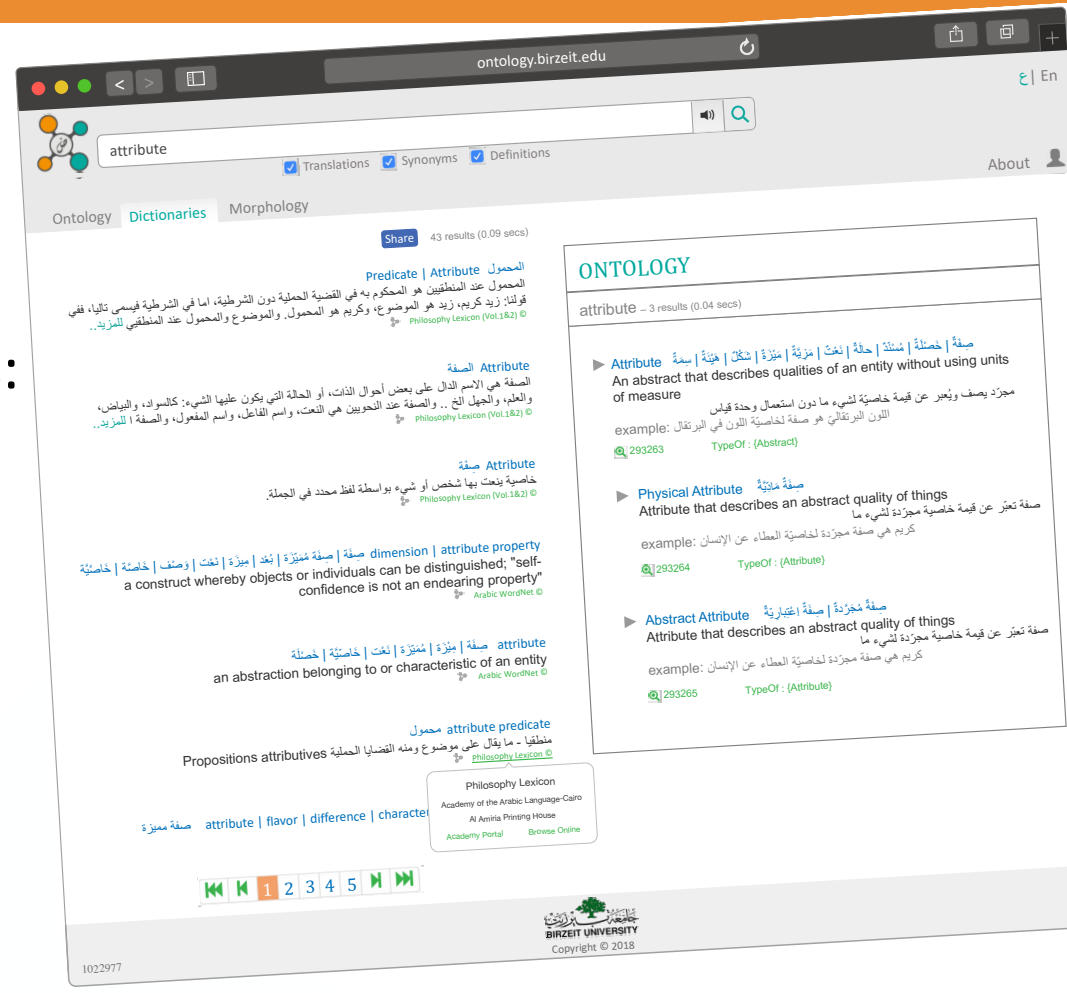
# Outline

- Overview of the Lexical Search Engine
- Usability Evaluation of Lexicographic e-Services.

# Overview of the Lexicographic Search Engine

# The Lexicographic Database

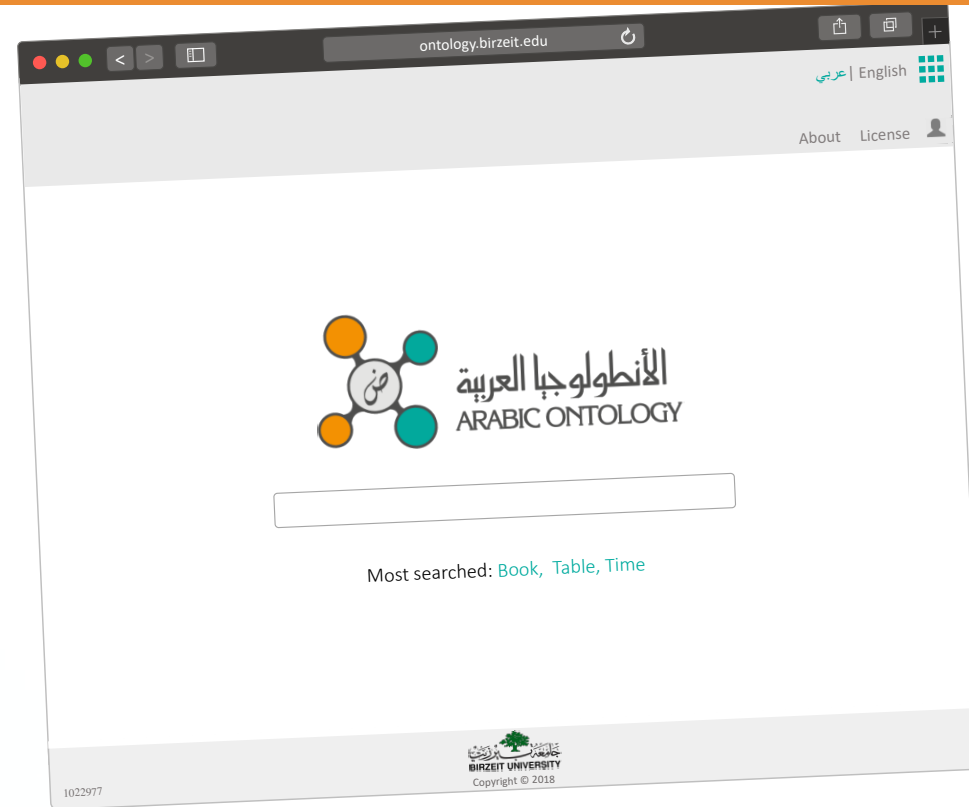
- The largest lexicographic Arabic database
- Contains most lexicon types: glossaries, thesauri, bi/trilingual dictionaries, morph datasets, **Arabic Ontology**, and more.
- Covers most domains: science, technology, law, business, art, philosophy, ...



<https://ontology.birzeit.edu>

# Lexicographic Search Engine

- **Free access to people:** students, translators, researchers, Arabic learners ...
- **API accessible** for NLP applications.



<https://ontology.birzeit.edu>

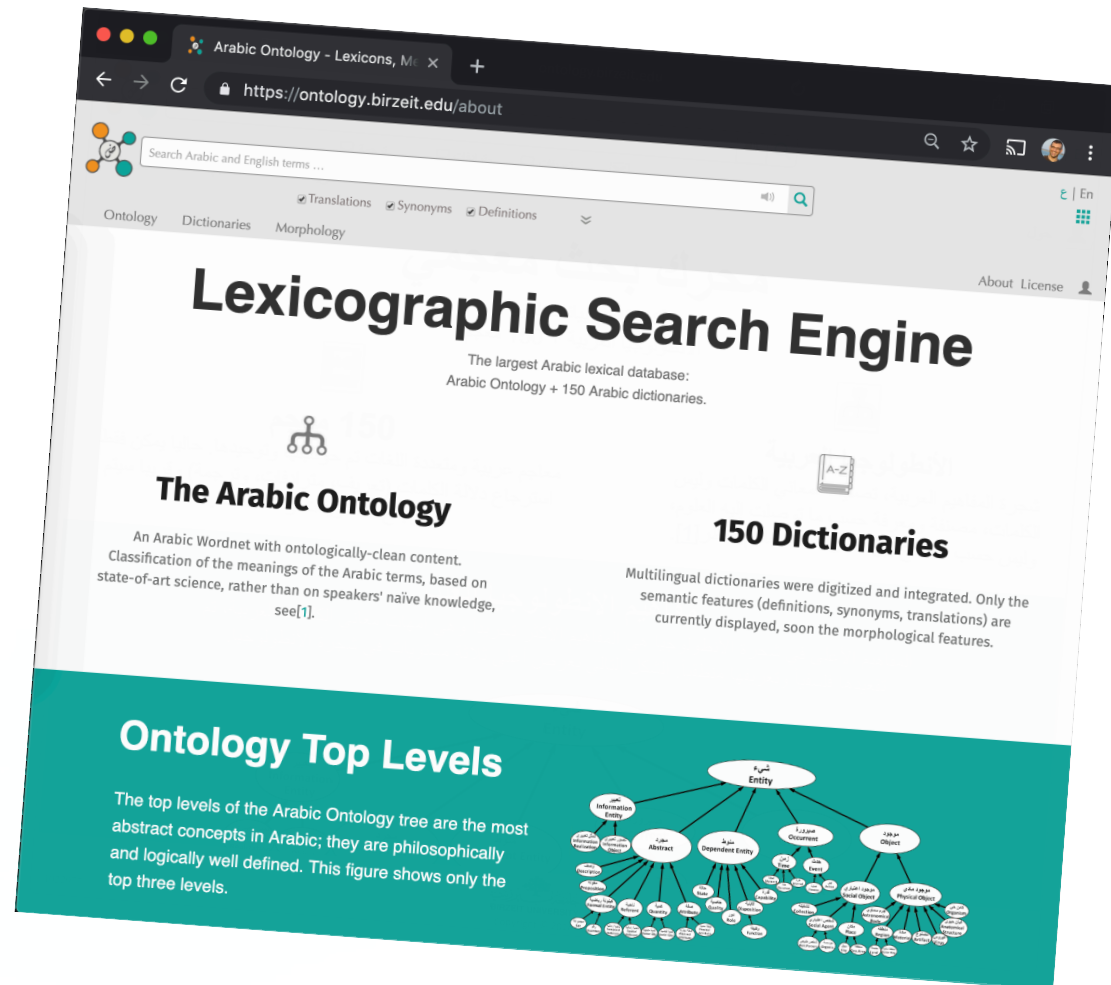
## Reference:

Mustafa Jarrar, Hamzeh Amayreh: **An Arabic-Multilingual Database with a Lexicographic Search Engine.** NLDB 2019. Pages(234--246), LNCS 11608, Springer. 2019.



# Lexicographic Search Engine

- **Search 150 lexicons** for definitions, synonyms, specialized translations, morphology, ontology [3,4] ...
- **Accurate!** compared with machine translation.
- **The first of its kind!** e.g., there are no similar search engines for English lexicons!



<https://ontology.birzeit.edu>

# Some Statistics

Currently!

Category	Lexical Concepts	Lexical entries	Synsets	Translations pairs	Glosses	Semantic relations
<b>Total (Millions)</b>	1.1 M	2.4 M	1.8 M	1.5 M	0.7 M	0.5 M
<b>Sub Counts</b>		1,100K Arabic 1,100K English 200K French 3K Others 1,300K Single-word 1,000K Multi-word	800K Arabic 800K English 200K French 50K Others	1,000K English-Arabic 300K English-French 200K French-Arabic	400K Arabic 300K English 1K Others	170K Sub-super links 29K Part-of links 260K Has-Domain links 30K Other links

For more, see [3]

# Obtaining Copyrights

- Obtained permission from each lexicons owner (individually contacted).
- Most accepted!
- Show lexicon name and © copyright symbol beside each result.
- Promote lexicons (click to see lexicon info)

The screenshot shows a web browser window with the URL [ontology.birzeit.edu](http://ontology.birzeit.edu). The search bar contains the word "attribute". Below the search bar, there are tabs for "Ontology", "Dictionaries", and "Morphology", with "Dictionaries" selected. The search results are displayed in a grid. On the right, there is a sidebar titled "ONTOLOGY" showing "attribute - 3 results (0.04 secs)". The main content area shows several results, each with a title in Arabic and English, a description, and a source. An orange arrow points from the text "Promote lexicons (click to see lexicon info)" to a button labeled "Philosophy Lexicon" in the bottom right corner of the search results. Below this button, there is a box containing the following text: "Philosophy Lexicon", "Academy of the Arabic Language-Cairo", "Al Amiria Printing House", and "Academy Portal Browse Online Buy".

attribute

Translations Synonyms Definitions

Ontology Dictionaries Morphology

Like Share 43 results (0.09 secs)

**المحمول** Predicate | **Attribute** المحمول  
المحمول عند المنطقين هو المحكوم به في القضية الحملية دون الشرطية، أما في الشرطية فيسمى تاليا، ففي قولنا: زيد كريم، زيد هو الموضوع، وكريم هو المحمول. والموضوع والمحمول عند المنطقي للمزيد..  
Philosophy Lexicon (Vol.1&2) ©

**الصفة** Attribute  
الصفة هي الاسم الدال على بعض أحوال الذات، أو الحالة التي يكون عليها الشيء: كالسواد، والبياض، والعلم، والجهل الخ.. والصفة عند النحويين هي النعت، واسم الفاعل، واسم المفعول، والصفة للمزيد..  
Philosophy Lexicon (Vol.1&2) ©

**صفة** Attribute  
خاصية ينعت بها شخص أو شيء بواسطة لفظ محدد في الجملة.  
Philosophy Lexicon (Vol.1&2) ©

**dimension | attribute property** صفة | صفة مُنمَّزة | بُد | ميزة | نعت | وصف | خاصية | خاصية  
a construct whereby objects or individuals can be distinguished; "self-confidence is not an endearing property"  
Arabic WordNet ©

**attribute** صفة | ميزة | مُنمَّزة | نعت | خاصية | خاصية  
an abstraction belonging to or characteristic of an entity  
Arabic WordNet ©

**attribute predicate** محمول  
منطقيًا - ما يقال على موضوع ومنه القضايا الحملية  
Philosophy Lexicon ©

**ONTOLOGY**  
attribute - 3 results (0.04 secs)

► **Attribute** صفة | صفة | صفة  
An abstract that describes qualities of an entity without using units of measure  
مجرد يصف ويُعبر عن قيمة خاصية لشيء ما دون استعمال وحدة قياس  
example: اللون البرتقالي هو صفة لخاصية اللون في البرتقال  
293263 TypeOf: (Abstract)

► **Physical Attribute** صفة مادية  
Attribute that describes an abstract quality of things  
صفة تعبر عن قيمة خاصية مجردة لشيء ما  
example: كريم هي صفة مجردة لخاصية العطاء عن الإنسان  
293264 TypeOf: (Attribute)

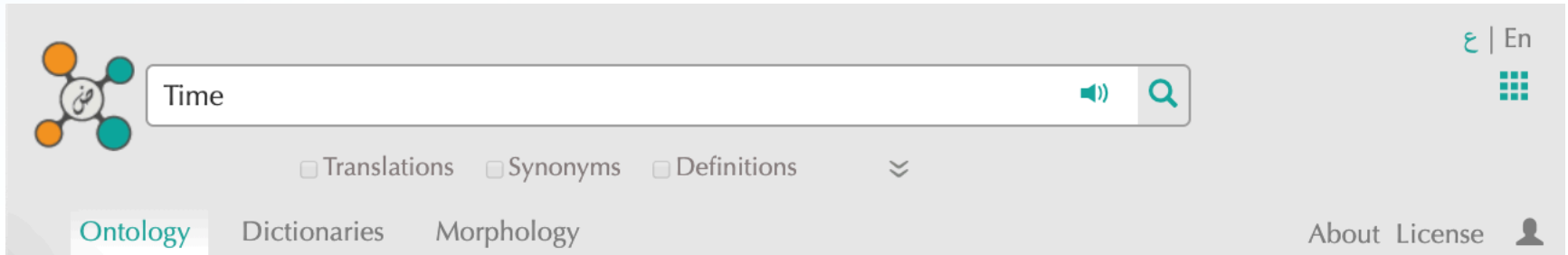
► **Abstract Attribute** صفة مجردة | صفة اعتبارية  
Attribute that describes an abstract quality of things  
صفة تعبر عن قيمة خاصية مجردة لشيء ما  
example: كريم هي صفة مجردة لخاصية العطاء عن الإنسان  
293265 TypeOf: (Attribute)

Philosophy Lexicon  
Academy of the Arabic Language-Cairo  
Al Amiria Printing House  
Academy Portal Browse Online Buy

1022977

# Search Taps

**Ontology tab:** results in this tab are ontology concepts retrieved only from the Arabic ontology. The tab also allows expanding and exploring the ontology tree. See [4,5] about the Arabic Ontology



Time

☐ Translations ☐ Synonyms ☐ Definitions

Ontology Dictionaries Morphology

About License

## ► time | مَدَّة | زَمَن | فَتْرَة

An occurrent representing a region in the timeline, realized by its starting and ending points, its length represents the temporal dimension of events or objects

مَجْرَد يُمَثِّل جُزْءاً مِنْ خَطِّ الزَّمَنِ الْمُدْرَكِ، تَدْرِكُ ذَاتَهُ بِنَقْطَةِ بَدَايَةٍ وَنَقْطَةِ نِهَايَةٍ طَوَّلُهَا يُمَثِّلُ زَمَنَ أَحْدَاثٍ أَوْ مَوْجُودَاتٍ

example: يستغرق دوران الأرض حول الشمس زمناً يعرف بالسنة

293570  TypeOf : {Occurrent}

## ► Interval | Time Interval | فَتْرَة | فَتْرَة زَمَنِيَّة

Amount of time, its length is calculated based on the the temporal dimension of astrological events, its starting and ending points are not equal, and has no gaps.

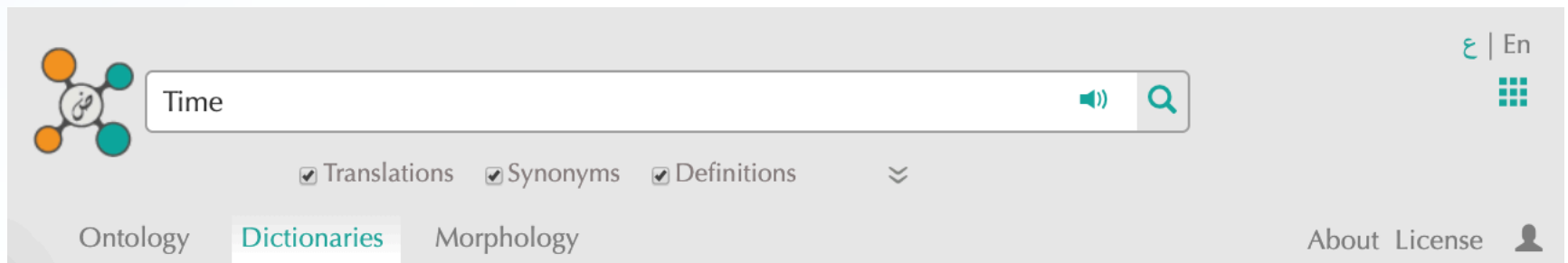
زَمَن يُكَمَّم وَيُحَسَبُ بِنَاءً عَلَى مَا يَنَاطُ بِهِ مِنْ أَحْدَاثٍ فَلَكَيَّةٍ، لَهُ بَدَايَةٌ وَنِهَايَةٌ غَيْرُ مُتَسَاوِيَةٍ، تَخْلُو مِنَ الثَّغَرَاتِ الزَّمَنِيَّةِ

example: الليل هو فترة زمنية بين غروب الشمس وشرورها

293572  TypeOf : {time}

# Search Taps

**Dictionaries tab:** results in this tab are lexical concepts retrieved from the lexicons.



Time

Translations Synonyms Definitions

Ontology **Dictionaries** Morphology

About License

time noun  
إِسْمُ زَمَانٍ  
اسم مشتق للدلالة على زمان وقوع الفعل  
Lexicon of Knowledge Engineering ©

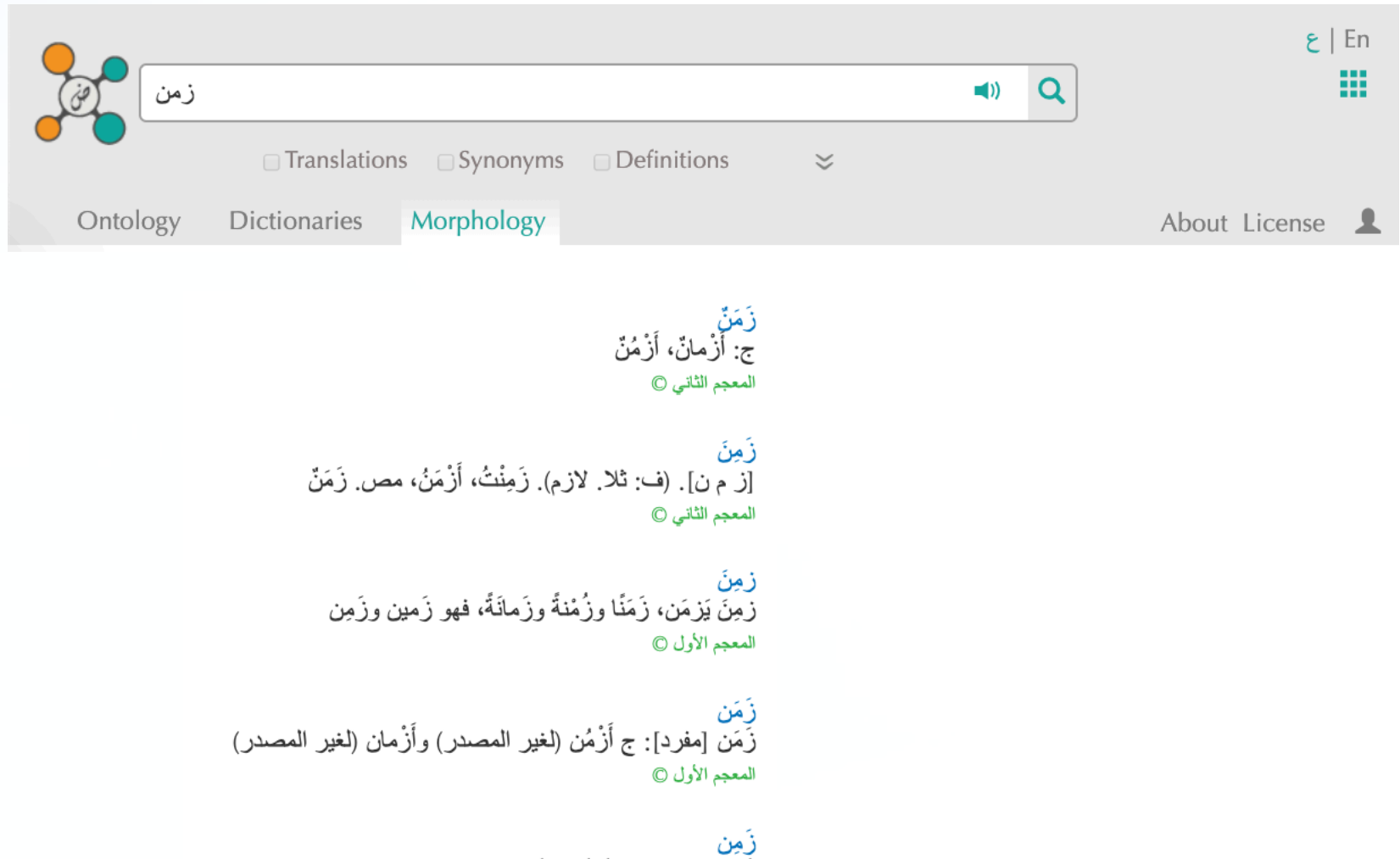
Time الزمان  
1 - الزمان الوقت كثيره وقليله. وهو المدة الواقعة بين حادثتين أولاهما سابقة وثانيتها لاحقة، ومنه زمان الحصاد، وزمان الشباب، وزمان الجاهلية. وجمع الزمان أزمنة، تقول: السنة أربعة أزمن للمزيد..  
Philosophy Lexicon (Vol.1&2) ©

Reaction-time زمان الانعكاس  
زمان الانعكاس هو المدة الواقعة بين وقت حدوث المؤثر ووقت رد الفعل. وله عدة أنواع كزمان الانعكاس البسيط، أو زمان الانعكاس لمؤثرين مختلفي الشدة، أو لمؤثرين متحدين، أو الإجابة بإشارة م للمزيد..  
Philosophy Lexicon (Vol.1&2) ©

time زمان  
وسط متجانس غير محدود تمر فيه الأحداث متلاحقة ، والمدة جزء منه . وقد يطلق على مدة معينة.  
Philosophy Lexicon ©

# Search Taps

**Morphology tab:** results are linguistic features, lemma(s), inflections, and derivations of the searched term (partially implemented!).



The screenshot displays the Search Taps application interface. At the top, there is a search bar containing the word 'زمن' (Zaman). To the right of the search bar are icons for voice search and a magnifying glass. Below the search bar, there are tabs for 'Translations', 'Synonyms', and 'Definitions', each with a checkbox. The 'Morphology' tab is currently selected and highlighted in blue. Below the tabs, there are links for 'About' and 'License', and a user profile icon. The main content area shows the morphological analysis of 'زمن' (Zaman). It lists the lemma 'زَمَنٌ' (Zaman) and its inflections: 'ج: أَزْمَانٌ، أَزْمُنٌ' (J: Azman, Azmun) from the 'المعجم الثاني' (Al-Mu'jam al-Thani) dictionary, and 'زَمَيْنَ' (Zamayna) from the 'المعجم الأول' (Al-Mu'jam al-Awwal) dictionary. It also shows the derivation 'زَمِنَ يَزِمْنُ، زَمَنًا وَزُمْنَةً وَزَمَانَةً، فَهُوَ زَمِينٌ وَزَمِينٌ' (Zamina yazimnu, zamanan wa zumnanah wa zamanah, fahu zaminun wa zaminun) from the 'المعجم الأول' (Al-Mu'jam al-Awwal) dictionary. The interface is in Arabic, with some English text like 'En' and 'About License'.

زمن

ع | En

Translations Synonyms Definitions

Ontology Dictionaries **Morphology** About License

زَمَنٌ  
ج: أَزْمَانٌ، أَزْمُنٌ  
المعجم الثاني ©

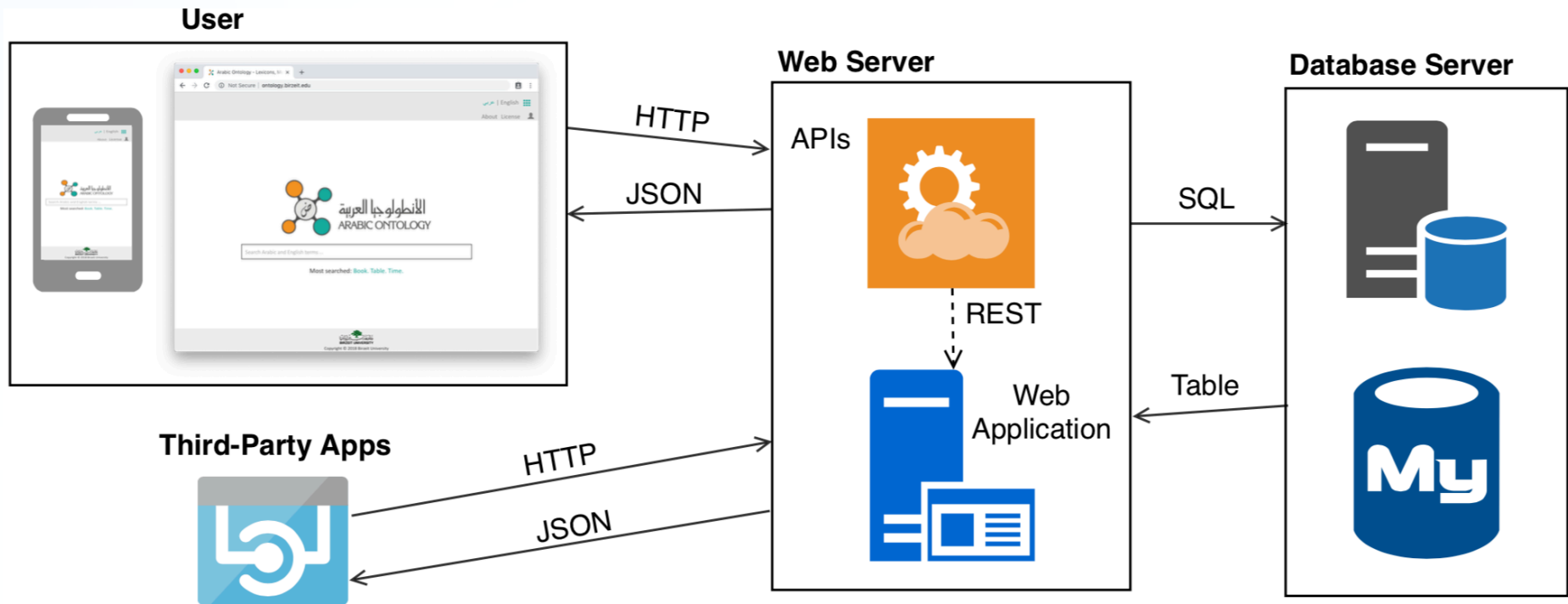
زَمَيْنَ  
[ز م ن]. (ف: ثلا. لازم). زَمِنْتُ، أَزْمِنُ، مص. زَمَنْ  
المعجم الثاني ©

زَمِنَ  
زَمِنَ يَزِمْنُ، زَمَنًا وَزُمْنَةً وَزَمَانَةً، فَهُوَ زَمِينٌ وَزَمِينٌ  
المعجم الأول ©

زَمَنَ  
زَمَنَ [مفرد]: ج أَزْمُنُ (لغير المصدر) وَأَزْمَانُ (لغير المصدر)  
المعجم الأول ©

زَمِنَ

# Search Engine Architecture



# Conformance with W3C Standards

## ✓ W3C's RDF Lemon Model

Represent (lexical entries, concepts, synsets, ...) using the Lemon RDF model

To interlink it with the [Linguistic Linked Open Data Cloud](#)

التسوية levelling | grading

تحريك التربة أثناء إعداد الأرض للري للوصول إلى سطح مستو أو سطح ذي انحدار منتظم.



Hydrology Lexicon ©

...

@prefix aot: <http://ontology.birzeit.edu/term/>.

@prefix aoc: <http://ontology.birzeit.edu/lexicalconcept/>.

@prefix aor: <http://ontology.birzeit.edu/lexicon/>.

<aoc:1623> a ontolex:LexicalConcept;

ontolex:isEvokedBy <aot:Lex-grading>;

ontolex:isEvokedBy <aot:Lex-levelling>;

ontolex:isEvokedBy <aot:Lex-تسوية>;

skos:definition "تحريك التربة أثناء إعداد الأرض للري للوصول إلى سطح مستو أو سطح..."@ar;

skos:inScheme <aor:Hydrology\_Lexicon\_1>.

<aot:lex-grading> a ontolex:LexicalEntry, ontolex:Word;  
ontolex:canonicalForm [ontolex:writtenRep "grading"@en];  
skos:inScheme <aor:Hydrology\_Lexicon\_1>.

<aot:lex-levelling> a ontolex:LexicalEntry, ontolex:Word;  
ontolex:canonicalForm [ontolex:writtenRep "levelling"@en];  
skos:inScheme <aor:Hydrology\_Lexicon\_1>.

<aot:lex-تسوية> a ontolex:LexicalEntry, ontolex:Word;  
ontolex:canonicalForm [ontolex:writtenRep "تسوية"@ar];  
skos:inScheme <aor:Hydrology\_Lexicon\_1>.

### Based On:

Mustafa Jarrar, Hamzeh Amayreh, John McCarae: **Progress on Representing Arabic Lexicons in Lemon**. The 2nd Conference on Language, Data and Knowledge (LDK 2019), Germany. 2019.



# Conformance with W3C Standards

- ✓ **W3C's Best Practices for Publishing Linked Data**  
including the Cool URIs, simplicity, stability, and linking

## URLs Schema:

- Each **term** is given a URL: `http://{domain}/term/{term}`  
<http://ontology.birzeit.edu/term/virus>
- Each **lexical concept** is given a URL:  
`http://{domain}/lexicalconcept/{lexicalConceptID}`  
<https://ontology.birzeit.edu/lexicalconcept/304000682>
- Each **concept** in the Arabic Ontology has a URL:  
`http://{domain}/concept/{ConceptID | Term}`  
<https://ontology.birzeit.edu/concept/293262>
- Each **Semantic relation** is given a URL:  
`http://{domain}/concept/{RelationName}/{ConceptID}`  
<https://ontology.birzeit.edu/concept/instances/293121>
- The **W3C Lemon representation of each lexical concept** is given a URL: `http://{domain}/lemon/lexicalconcept/{lexicalConceptID}`  
<https://ontology.birzeit.edu/lemon/lexicalconcept/304000682>

# API Access

RESTful web services

Ask us for an API Key!

## LexAPI v1.0

LexAPI 1.0 is a set of RESTful webservices that all together form an API for other third-party software developers to retrieve linguistic data from the [lexicographic search engine](#).

This page explains APIs with example links on each.  
A click on one of the links will send the request to the corresponding API and the returned JSON object will appear inside the Output box on the right.

### APIs:

- + Search Dictionaries for a term:
- + Search Arabic Ontology for a term:
- + Retrieve a lexical concept:
- + Retrieve an Arabic Ontology concept:
- + Retrieve Morphology information:
- + Autocomplete Service:
- + Retrieve subtypes of an Ontology concept:
- + Retrieve concepts part of another concept:

### Output (JSON):

```
{
  "conceptID":1520039900,"arabicGloss":null,"englishGloss":"the fourth coordinate that is required (along with three spatial dimensions) to specify a physical event","tags":null,"example":null,"lang":null,"dataSourceId":152,"synsetFrequency":null,"dataSourceCacheAr":"شبكة المفردات العربية","dataSourceCacheEn":"Arabic WordNet","englishWordsCache":"| بُعْد زَايِع | وَت | زَمَن","superId":1520039870,"superOrder":0,"superTypeCacheAr":"| بُعْد","superTypeCacheEn":"dimension","categoryId":null,"area":null,"era":null,"rank":null,"status":null,"subTypesCount":0,"partOfCount":0,"instancesCount":0,"instanceOfID":null,"undiacritizedArabicWordsCache":"| بُعْد زَايِع | وَت | زَمَن dimension | time |","normalizedEnglishWordsCache":"| fourth dimension | time |","exactWord":null}
```

# Ranking Metrics

We developed three strategies:

- ❖ **Citation strategy ( $R_{cit}$ )** frequency of the lexical concept terms:

$$R = \sum_{n=1}^{|A|} \sum_{m=1}^k F_{a_{nm}}$$

$$R_{cit} = \frac{R - R_{min}}{R_{max} - R_{min}}$$

- ❖ **Lexicon renown ranking strategy ( $R_{ren}$ ):** experts assigned each lexicon a rank based on its renown.

- ❖ **Hybrid ranking strategy ( $R_{hyb}$ )** is a combination metric:

$$R_{hyb} = R_{ren} + R_{cit}$$

The screenshot shows a web browser at ontology.birzeit.edu with a search bar containing 'attribute'. Below the search bar, there are tabs for 'Ontology', 'Dictionaries', and 'Morphology'. The 'Dictionaries' tab is active, showing search results for 'attribute'. The results are organized into sections: 'Attribute' (with a definition in Arabic and English), 'Physical Attribute' (with a definition in Arabic and English), and 'Abstract Attribute' (with a definition in Arabic and English). Each section includes an example and a 'TypeOf' label. The page also features a 'Like' button, a 'Share' button, and a '43 results (0.09 secs)' indicator. At the bottom, there is a footer with the Birzeit University logo and copyright information.

# Usability Evaluation of Lexicographic e-Services

- 1) Subjective user-experience
- 2) Objective controlled experiment

# Subjective User-Experience

## Online Survey

<https://ontology.birzeit.edu/s>

## Survey Design:

- 16 Questions
- Q1-Q4 collected general information
- Q5-Q16 are the core of the survey, targeting Effectiveness, Efficiency, Satisfaction, Learnability

## Data Collection:

- 1000 questionnaires were distributed over a period of 2 months.
- 622 valid responses acquired

استبيان محرك البحث المعجمي

نشكركم على تعاونكم معنا لتقييم محرك البحث المعجمي (<http://ontology.birzeit.edu>)

نحتاج دقيقتين فقط لتعبئة هذا الاستبيان

رأيك يهمنا جداً، وسنعمل جاهدين على تحديث محرك البحث بناءً على هذا الاستبيان

1. هل انت؟

طالب	كاتب	باحث	موظف
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. كم عمرك؟

اقل من 18	18-25	25-30	اكثر من 30
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. ما هو هدفك من استخدام محرك البحث؟

☐ البحث عن المعاني والتعريفات

☐ البحث عن التراجم

☐ البحث عن المترافات

4. ما هو عدد الكلمات التي بحثت عنها في محرك البحث قبل تعبئة هذا الاستبيان؟

كلمة واحدة	اكثر من 5 كلمات	اكثر من 20 كلمة
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. هل الخطوط والالوان مريحة وجذابة؟

ممتاز	جيد	مقبول	ضعيف	لم اهتم السؤال
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

# Summary of Survey Results

## Respondents' Backgrounds (Q1-Q2)

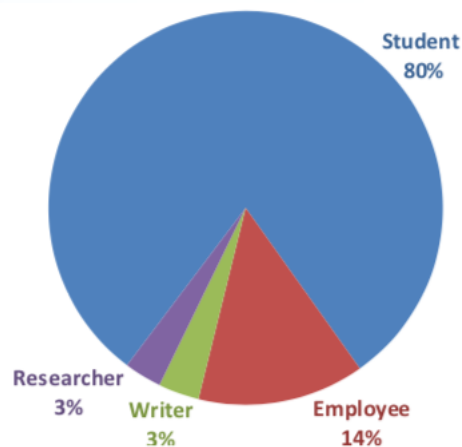


Fig. 2. Respondents' professions

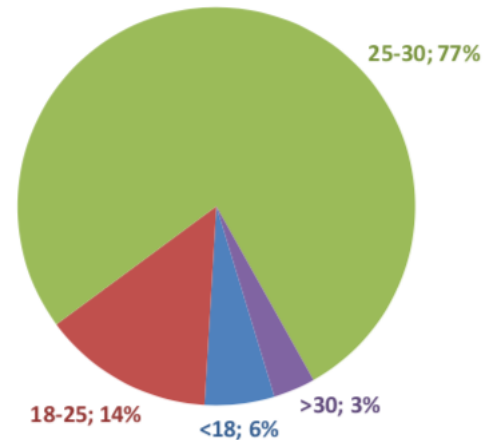


Fig. 3. Respondents' age groups

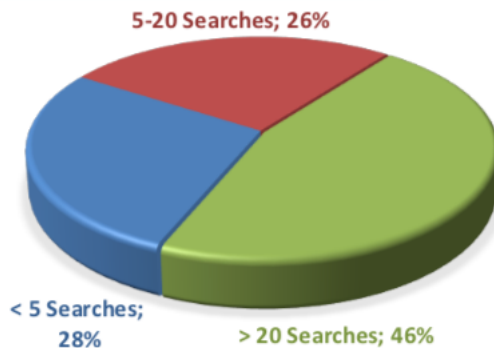


Fig. 5. Frequency of use

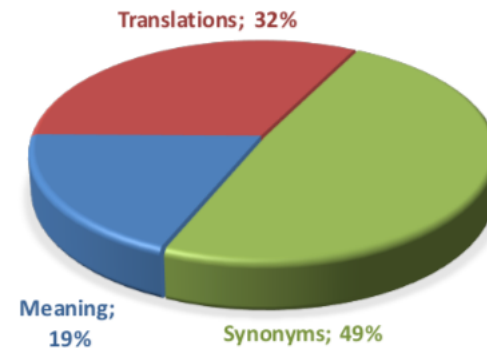
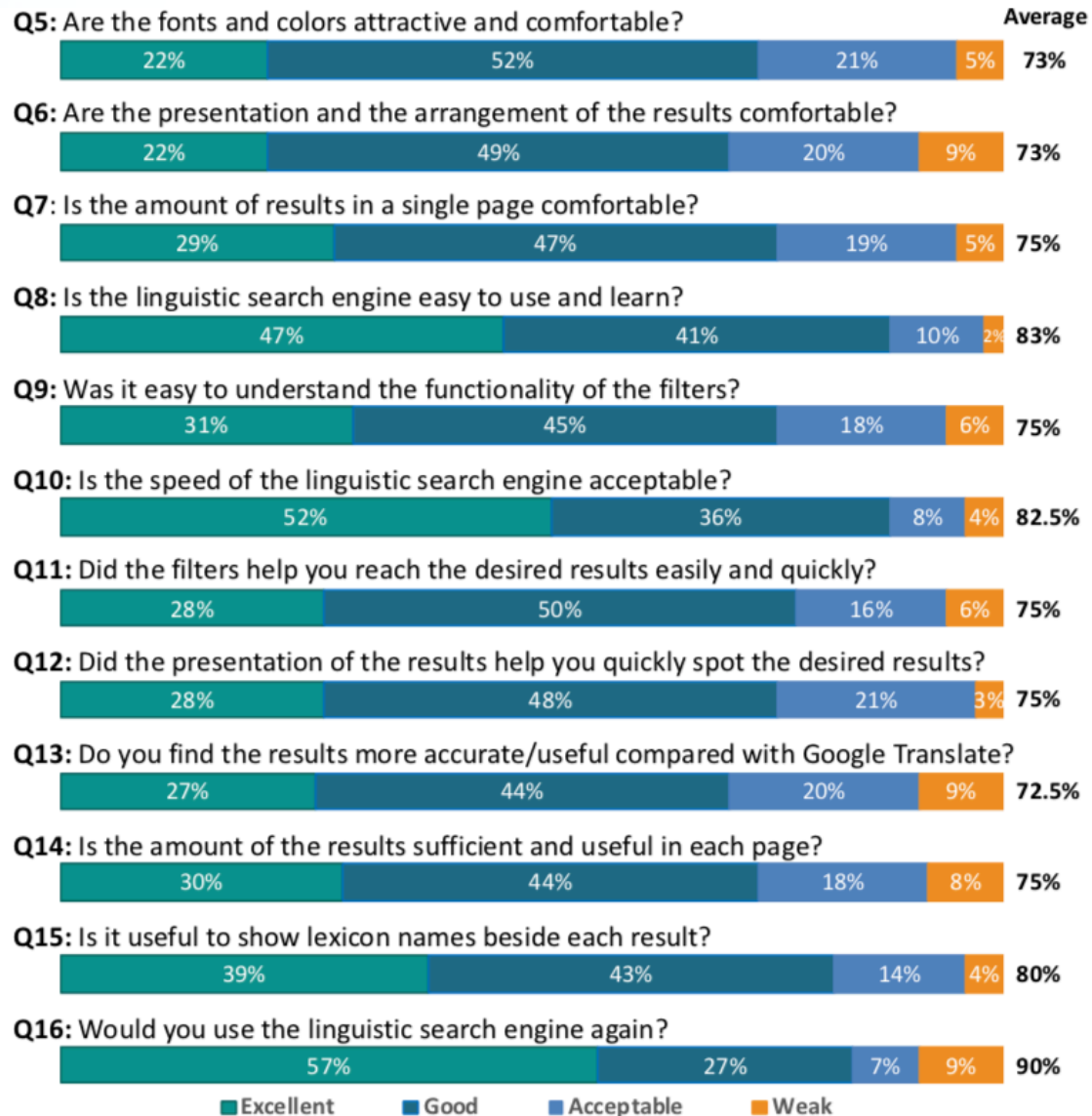


Fig. 4. Purpose of use

# Summary of Survey Results



# Summary of Survey Results

## Subjective user-experience

Criterion	Satisfaction	Learnability	Efficiency	Effectiveness	Average
Questions	Q5-Q7	Q8-Q9	Q10-Q12	Q13-Q16	Q5-Q16
Average	73%	83%	75%	80%	<b>77.8%</b>



# Control Experiment

- Eight tasks were carried out in a controlled environment, in a lab environment
- Four types of tasks: (i) synonyms, (ii) meanings, (iii) translation, and (iv) semantic differences between terms.
- Measure the efficiency and effectiveness of both Google Translate and the lexicographic search engine.
- Two groups (A and B), each consisted of 3 participants (12 in total).
- 10 minutes tutorial to try both tools.

<p><b>Task 1</b> Suggest the best synonyms to replace <b>elaborated</b>, without changing the meaning of the sentence:  <i>The main idea of this lesson is <u>elaborated</u> in the textbook.</i>          Synonym 1: _____ Synonym 2: _____</p>	<p><b>Task 2</b> Suggest best synonyms to replace <b>صيرورة</b>, without changing the meaning of the sentence:  <i>العملية الديمقراطية تعمل بقوة وزخم في اللحظة الراهنة.</i>          Synonym 1: _____ Synonym 2: _____</p>	Synonyms
<p><b>Task 3</b> What is the meaning of <b>account</b> in the following sentence:  <i>This report does not provide a sufficient <u>account</u> for constructing a hospital in this area.</i>          Meaning 1: _____ Meaning 2: _____</p>	<p><b>Task 4</b> What is the meaning of <b>رتاج</b> in the following  <i>لم يعجبه رتاج القصر.</i>          Meaning 1: _____ Meaning 2: _____</p>	
<p><b>Task 5</b> Translate the following sentence to English (without using machine translation):  <i>التقيت بهذا الرجل المتعطر.</i>          Translation 1: _____ Translation 2: _____</p>	<p><b>Task 6</b> Translate the following sentence to English (without using machine translation):  <i>The proliferation of technology has limited our interaction and exposure to nature.</i>          Translation 1: _____ Translation 2: _____</p>	
<p><b>Task 7</b> What is the semantic difference between <b>الوقار</b> and <b>الرزانة</b>?          Answer 1: _____ Answer 2: _____</p>	<p><b>Task 8</b> What is the semantic difference between <b>أعجمي</b> and <b>عجمي</b>?          Answer 1: _____ Answer 2: _____</p>	Meaning Translation Semantics

# Summary of the Control Experiment Results

Table II. Task Time (in seconds) by participant by task

Participants			Tasks								Mean time
			T1	T2	T3	T4	T5	T6	T7	T8	
Group A: LSE	BZU	P1	58	27	40	20	45	80	116	95	60
		P2	43	17	62	30	53	50	116	118	61
		P3	30	24	37	51	50	113	115	96	65
	PTUK	P4	110	39	60	31	25	195	123	85	84
		P5	116	48	77	43	27	190	120	77	87
		P6	50	40	67	43	37	160	150	102	81
Meantime			68	33	57	36	40	131	123	96	73
Group B: GT	BZU	P7	90	25	50	30	61	85	60	70	59
		P8	120	14	120	61	50	128	60	30	73
		P9	110	30	80	60	71	220	60	30	83
	PTUK	P10	27	26	40	15	18	75	11	12	28
		P11	37	27	43	11	22	85	17	30	34
		P12	14	20	44	30	30	90	30	11	34
Meantime			66	24	63	35	42	114	40	31	52

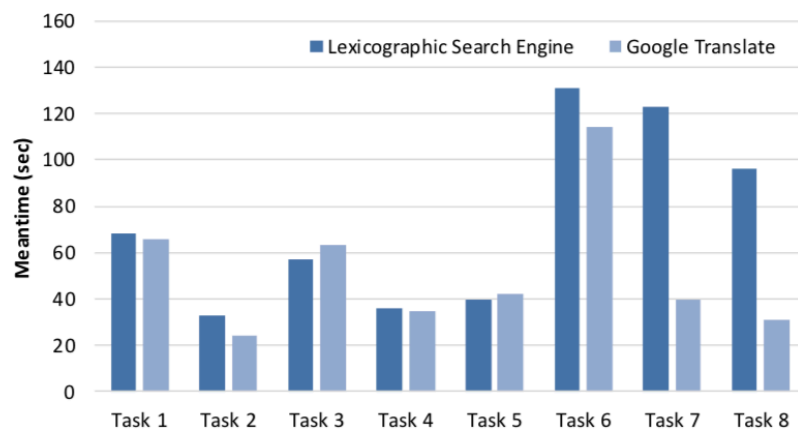


Fig. 8. Meantime, in seconds, for each task (i.e., efficiency)

Table III. Task Score by participant by task

Participants			Tasks								Avg
			T1	T2	T3	T4	T5	T6	T7	T8	
Group A: LSE	BZU	P1	8	10	10	10	10	8	10	10	9.50
		P2	6	10	4	8	10	6	6	8	7.25
		P3	10	10	10	10	6	8	6	6	8.25
	PTUK	P4	10	10	0	10	8	6	8	8	7.50
		P5	8	10	0	6	4	10	6	10	6.75
		P6	8	10	8	8	8	8	6	8	8.00
Average			8.33	10	5.66	8.66	7.66	7.66	7.00	8.33	7.91
Group B: GT	BZU	P7	0	0	4	4	10	8	0	0	3.25
		P8	8	0	4	0	6	10	0	0	3.50
		P9	8	0	10	0	8	8	0	0	4.25
	PTUK	P10	8	0	2	0	6	8	0	0	3.00
		P11	4	0	4	4	6	4	0	0	2.75
		P12	10	0	4	0	4	8	0	0	3.25
Average			6.33	6.67	4.66	4	6.66	7.66	0	0	4.5

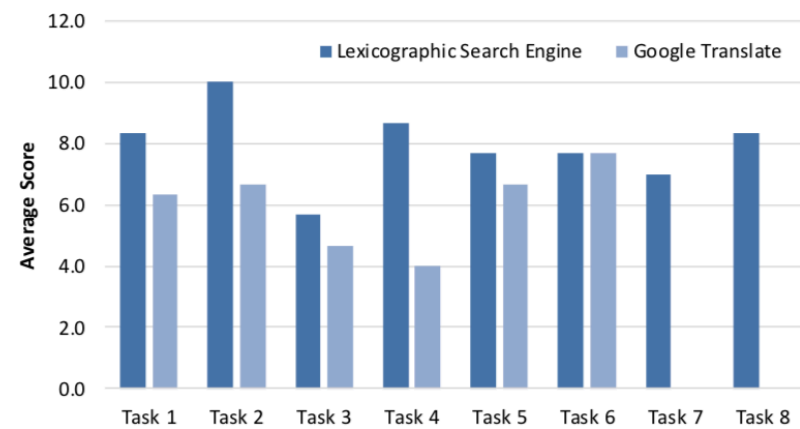


Fig. 9. Average task scores for both tools (i.e., effectiveness)

# Comparing both Approaches

**subjective** user-experience      Vs.      **objective** controlled experiment

Criterion	Satisfaction	Learnability	Efficiency	Effectiveness	Average
Questions	Q5-Q7	Q8-Q9	Q10-Q12	Q13-Q16	Q5-Q16
Average	73%	83%	75%	80%	77.8%

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			T1	T2	T3	T4	T5	T6	T7	T8	
Group A: LSE	BZU	P1	58	27	40	20	45	80	116	95	60
		P2	43	17	62	30	53	50	116	118	61
		P3	30	24	37	51	50	113	115	96	65
	PTUK	P4	110	39	60	31	25	195	123	85	84
		P5	116	48	77	43	27	190	120	77	87
		P6	50	40	67	43	37	160	150	102	81
Meantime			68	33	57	36	40	131	123	96	73

Participants			Tasks								Avg
			T1	T2	T3	T4	T5	T6	T7	T8	
Group A: LSE	BZU	P1	8	10	10	10	10	8	10	10	9.50
		P2	6	10	4	8	10	6	6	8	7.25
		P3	10	10	10	10	6	8	6	6	8.25
	PTUK	P4	10	10	0	10	8	6	8	8	7.50
		P5	8	10	0	6	4	10	6	10	6.75
		P6	8	10	8	8	8	8	6	8	8.00
Average			8.33	10	5.66	8.66	7.66	7.66	7.00	8.33	7.91

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