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search-query: An Open-Source Python Library for Academic Search Queries

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Summary

search-query is an open-source Python library designed to load, lint, translate, save, improve, and automate academic literature search queries. Unlike existing proprietary and web-based tools, *search-query* offers programmatic access and thereby supports integration into research workflows, contributing to the automation of systematic literature reviews. It currently provides query translation between Web of Science, PubMed, and EBSCOHost, while its validation features detect syntactical errors and inconsistencies that may compromise queries. The parsers for these three databases are tested against a comprehensive set of peer-reviewed queries from searchRxiv. By addressing key gaps in literature search tools, *search-query* contributes to the correctness and efficiency of systematic reviews and meta-analyses.

Keywords: Python, search query, literature search, literature review.

Statement of Need

Researchers conducting meta-analyses and other types of literature reviews rely on database searches as the primary search technique (Hiebl, 2023). This primarily includes the design of Boolean queries, and the execution in academic databases. Requirements include: (1) query translation, i.e., parsing a query in one database specific syntax and serializing it in another syntax (e.g., Al-Zubidy & Carver, 2019; Sturm & Sunyaev, 2019), (2) query validation, i.e., identifying syntactical errors or warning of known database errors (e.g., Li & Rainer, 2023; Singh & Singh, 2017), (3) query improvement, i.e., manipulation of query objects to understand and enhance performance (e.g., Scells et al., 2020), and (4) integration capability, i.e., offering programmatic or API access to integrate in a tool pipeline (e.g., Beller et al., 2018; O'Connor et al., 2018).

Overview of search-query Functionality

search-query aims to support the entire process of managing academic search queries. Its core functionality is shown in Figure 1 and summarized in the following.

- **Load:** *search-query* provides parsing capabilities to ingest search queries from both raw strings and JSON files. It parses database-specific query strings into internal, object-oriented representations of the search strategy. This allows the tool to capture complex Boolean logic and field restrictions in a standardized form. Currently, parsers are available for Web of Science, PubMed, and EBSCOHost. The *load* functionality is extensible and the documentation outlines how to develop parsers for additional databases.
- **Lint:** *search-query* can apply linters to detect syntactical errors or inconsistencies that might compromise the search. It can check for issues such as unbalanced parentheses,

logical operator misuse, or database-specific syntax errors. The validation rules are based on an analysis of a large corpus of real-world search strategies from the searchRxiv registry, revealing that many published queries still contained errors even after peer review. By identifying such problems early, linters can help researchers validate and refine queries before execution. The linting component can be updated to cover more databases and incorporate new messages, such as warnings for database-specific quirks.

- **Translate:** The library can convert a query from one database syntax into another, enabling cross-platform use of search strategies. Using a generic query object as an intermediate representation, *search-query* currently supports translations between Web of Science, PubMed, and EBSCOHost. Such query translation functionality can eliminate manual efforts for rewriting queries and reduce the risk of human error during translation. In line with the vision of seamless cross-database literature searches, future development will focus on adding more databases to the translation repertoire.
- **Save:** After validation and refinement, *search-query* can serialize the query object back into a standard string or file format for reporting and reuse. In practice, this means that a query constructed or edited within the tool can be exported as a well-formatted search string that is ready to be executed in a database or included in the methods section of a paper. This facilitates transparency and reproducibility by allowing search strategies to be easily reported, shared or deposited.
- **Improve:** Beyond basic syntax checking and translation, *search-query* aims to support semantic query improvement to enhance recall and precision. As queries are represented as manipulable objects, researchers can programmatically experiment with modifications — for example, adding synonyms or adjusting field scopes — to observe how these changes affect the search results. In future work, this improvement functionality may be augmented with more automated suggestions and optimizations.
- **Automate:** Finally, *search-query* is designed to support advanced automation efforts and to integrate with systematic review management systems, such as CoLRev (Wagner & Prester, 2025). The library offers programmatic access via its Python API, which means it can be embedded in scripts and pipelines to run searches or process queries without manual intervention. It also provides a command-line interface and git pre-commit hooks, allowing researchers to incorporate query validation into version control and continuous integration setups. By representing queries in the form of objects, *search-query* further enables advanced use cases such as executing searches on platforms that lack native Boolean query support, for instance, by breaking a complex query into multiple API calls.

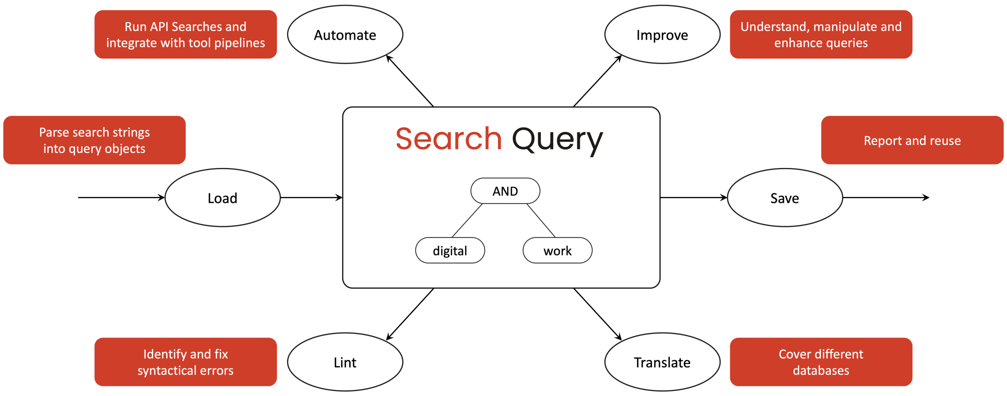

Run API Searches and integrate with tool pipelines
Automate
Improve
Understand, manipulate and enhance queries
Parse search strings into query objects
Search Query
Report and reuse
Load
AND
Save
digital
work
Identify and fix syntactical errors
Lint
Translate
Cover different databases

Figure 1: Core functionality of the *search-query* library

Example Usage

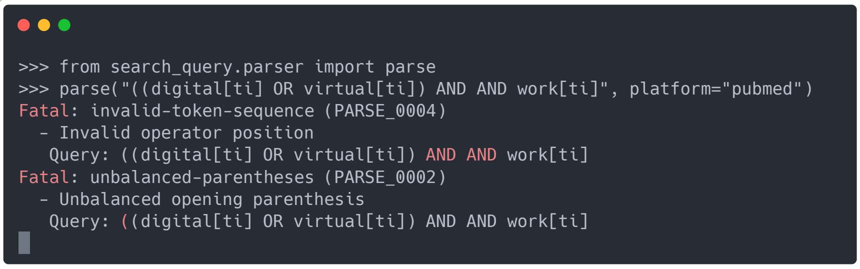
Load

```python
# Option 1: Parse query file
from search_query.search_file import load_search_file

search_file = load_search_file("search-file.json")
wos_query = parse(search_file.search_string, platform=search_file.platform)

# Option 2: Parse query string
from search_query.parser import parse

wos_query = parse("digital AND work", platform="wos")

# Option 3: Construct query programmatically
from search_query import OrQuery, AndQuery

digital_synonyms = OrQuery(["digital", "virtual", "online"])
work_synonyms = OrQuery(["work", "labor", "service"])
query = AndQuery([digital_synonyms, work_synonyms], field="title")

# Option 4: Load query from database
from search_query.database import load_query

FT50_journals = load_query("journals_FT50")
```

Lint

The parser automatically emits linter messages that identify defects and provide suggestions for improvement. This helps researchers maintain high-quality—even in complex search strategies. In fact, search queries used in literature reviews are often long and complex: peer-reviewed queries from searchRxiv, for instance, average over 2,900 characters and include around 60 parentheses. Such queries are difficult to analyze visually—both for researchers constructing them and for reviewers assessing their validity. The linters identify six categories of issues, which are illustrated briefly in the following.

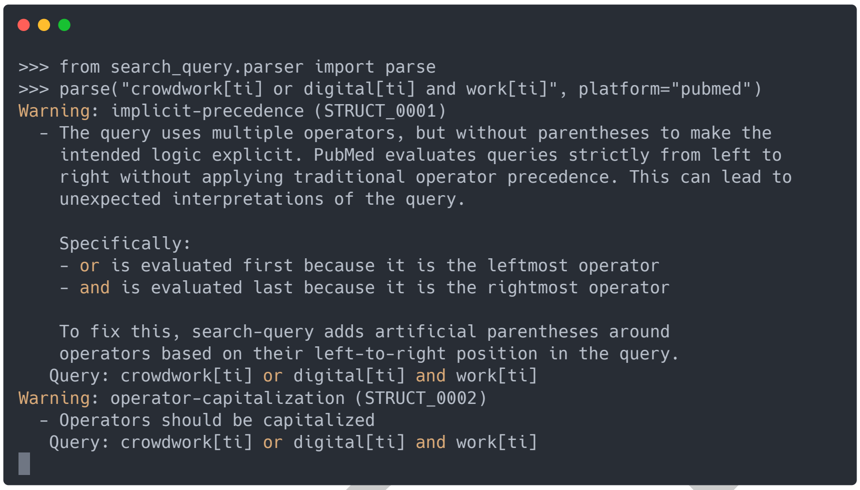
Parse errors highlight critical syntax issues that prevent a query from being parsed. Typical examples include unmatched parentheses, misplaced logical operators, or invalid token sequences. These errors usually require correction before any further processing or database execution is possible.



```
>>> from search_query.parser import parse
>>> parse("((digital[ti] OR virtual[ti]) AND AND work[ti]", platform="pubmed")
Fatal: invalid-token-sequence (PARSE_0004)
  - Invalid operator position
    Query: ((digital[ti] OR virtual[ti]) AND AND work[ti]
Fatal: unbalanced-parentheses (PARSE_0002)
  - Unbalanced opening parenthesis
    Query: ((digital[ti] OR virtual[ti]) AND AND work[ti]
```

Figure 2: Examples of parse errors

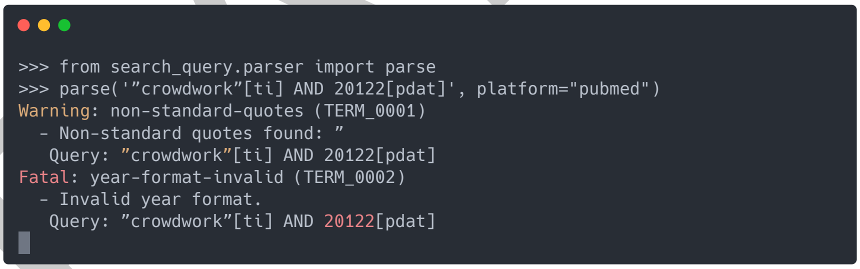
Structure warnings highlight issues that affect the validity or clarity of a query's logical structure, such as implicit operator precedence or inconsistent capitalization of Boolean operators. These warnings help ensure that the intended logic is clear and that the query remains readable and easy to verify.



```
>>> from search_query.parser import parse
>>> parse("crowdwork[ti] or digital[ti] and work[ti]", platform="pubmed")
Warning: implicit-precedence (STRUCT_0001)
  - The query uses multiple operators, but without parentheses to make the
    intended logic explicit. PubMed evaluates queries strictly from left to
    right without applying traditional operator precedence. This can lead to
    unexpected interpretations of the query.

    Specifically:
    - or is evaluated first because it is the leftmost operator
    - and is evaluated last because it is the rightmost operator

    To fix this, search-query adds artificial parentheses around
    operators based on their left-to-right position in the query.
   Query: crowdwork[ti] or digital[ti] and work[ti]
Warning: operator-capitalization (STRUCT_0002)
  - Operators should be capitalized
   Query: crowdwork[ti] or digital[ti] and work[ti]
```

Figure 3: Examples of structral warnings

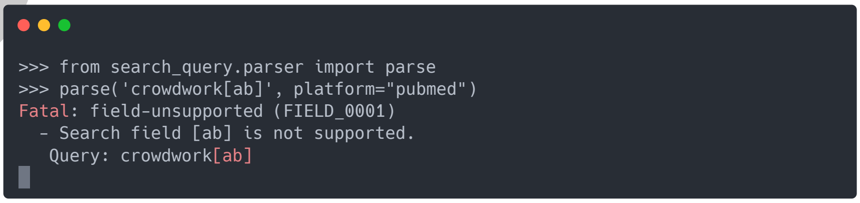
Term warnings identify suspicious or malformed search terms, such as non-standard quotes or invalid date formats. These issues may cause databases to interpret the terms incorrectly or fail to return relevant results.



```
>>> from search_query.parser import parse
>>> parse('”crowdwork”[ti] AND 20122[pdat]', platform="pubmed")
Warning: non-standard-quotes (TERM_0001)
  - Non-standard quotes found: ”
   Query: ”crowdwork”[ti] AND 20122[pdat]
Fatal: year-format-invalid (TERM_0002)
  - Invalid year format.
   Query: ”crowdwork”[ti] AND 20122[pdat]
```

Figure 4: Examples of term warnings

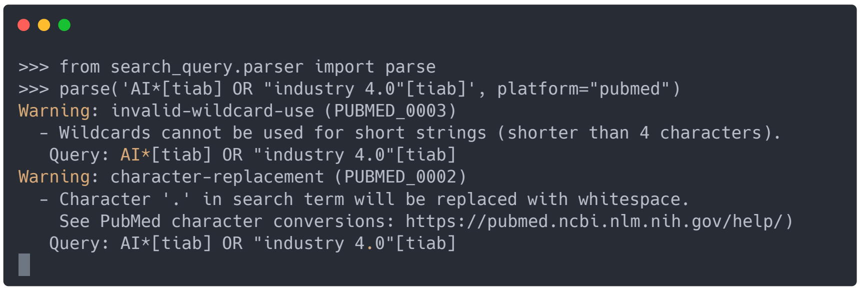
Field warnings point to missing, implicit, or unsupported field tags. These issues may lead to incorrect interpretations or cause the query to fail during execution in the database.



```
>>> from search_query.parser import parse
>>> parse('crowdwork[ab]', platform="pubmed")
Fatal: field-unsupported (FIELD_0001)
  - Search field [ab] is not supported.
   Query: crowdwork[ab]
```

Figure 5: Examples of field warnings

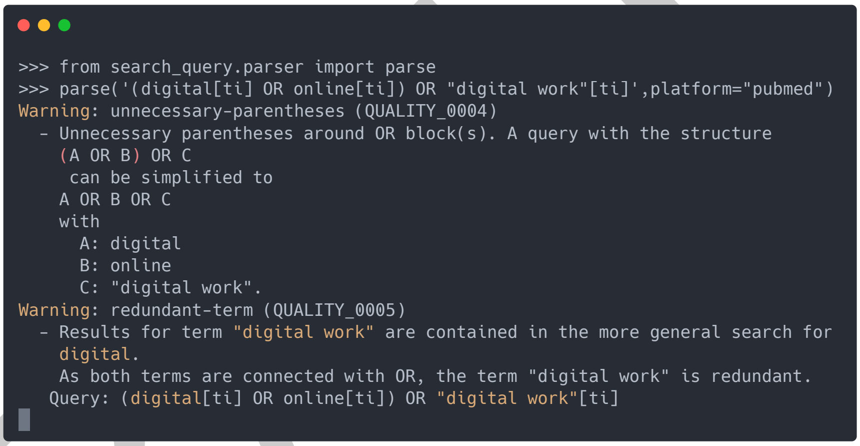
Database-specific warnings flag platform-specific quirks and limitations that may not be obvious to users. These include constraints on wildcard usage, invalid characters, and limitations of proximity operators. These issues can cause queries to execute incorrectly or fail, despite appearing syntactically valid.



```
>>> from search_query.parser import parse
>>> parse('AI*[tiab] OR "industry 4.0"[tiab]', platform="pubmed")
Warning: invalid-wildcard-use (PUBMED_0003)
  - Wildcards cannot be used for short strings (shorter than 4 characters).
   Query: AI*[tiab] OR "industry 4.0"[tiab]
Warning: character-replacement (PUBMED_0002)
  - Character '.' in search term will be replaced with whitespace.
    See PubMed character conversions: https://pubmed.ncbi.nlm.nih.gov/help/)
   Query: AI*[tiab] OR "industry 4.0"[tiab]
```

Figure 6: Examples of database-specific warnings

Quality warnings offer best practice recommendations for constructing effective search queries. These include alerts about redundant terms, unnecessary parentheses or complex query structures.



```
>>> from search_query.parser import parse
>>> parse('(digital[ti] OR online[ti]) OR "digital work"[ti]',platform="pubmed")
Warning: unnecessary-parentheses (QUALITY_0004)
  - Unnecessary parentheses around OR block(s). A query with the structure
    (A OR B) OR C
     can be simplified to
    A OR B OR C
    with
      A: digital
      B: online
      C: "digital work".
Warning: redundant-term (QUALITY_0005)
  - Results for term "digital work" are contained in the more general search for
    digital.
    As both terms are connected with OR, the term "digital work" is redundant.
   Query: (digital[ti] OR online[ti]) OR "digital work"[ti]
```

Figure 7: Examples of quality warnings

In addition, it is possible to access linter messages programmatically:

```python
from search_query.linter import lint_file

messages = lint_file(search_file)
```

Translate

```python
query_string = '("dHealth"[Title/Abstract]) AND ("privacy"[Title/Abstract])'
pubmed_query = parse(query_string, platform="pubmed")
wos_query = pubmed_query.translate(target_syntax="wos")
print(wos_query.to_string())
# Output:
# (AB="dHealth" OR TI="dHealth") AND (AB="privacy" OR TI="privacy")
```

Save

```python
pubmed_query.to_string()
```

Functionality to improve and automate search queries focuses on the programmatic use of *search-query* for custom logic and use cases (e.g., writing tailored functions). As these features are designed for flexible integration into code-based workflows, it is hard to illustrate them through generic examples; instead, guidance can be found in the online documentation.

Related tools

Table 1 provides an overview of related tools and a comparison with *search-query*. The leading query translators, Polyglot search and Litsonar, are proprietary and delivered through websites without further integration capabilities. Polyglot search supports a more comprehensive selection of databases (15) and initial validation hints (Clark et al., 2020). Litsonar supports seven databases, serializes queries entered through the web interface, but does not offer parsers (Sturm & Sunyaev, 2019). As tools available under open-source licenses, Medline Transpose (Wanner & Baumann, 2019) is a javascript-based website that translates queries between three databases, and litsearchr (Grames, 2020) is an R library that supports semi-automated generation of queries based on text-mining techniques.

Tool	Setup	License	*Load*	*Lint*	*Translate*	*Save*	*Improve*	*Automate*
Polyglot search	Website	Proprietary	○	○	●	●	-	○
LitSonar	Website	Proprietary	○	-	●	●	-	○
Medline Transpose	Website	MIT	○	-	●	●	-	○
litsearchr	R library	GPL-3	○	-	-	●	●	●
search-query	Python	MIT	●	●	●	●	●	●

Table 1: Overview of related tools (- no support, ○ limited support, ● support)

In comparison to related tools, *search-query* provides a Python library, released under the MIT open-source license. It is extensible and currently supports three databases (Web of Science, PubMed, EBSCOHost) for query translation and query validation. The query parsers were tested with a comprehensive selection of peer-reviewed queries from searchRxiv (White, 2024). Testing showed that a significant number of queries still contained errors after passing the peer-review process, further highlighting the need for syntax validation tools like *search-query*.

Acknowledgments and Outlook

The development of *search-query* originated from a series of student thesis projects supervised at the Digital Work Lab, Otto-Friedrich-Universität Bamberg (Eckhardt, 2025; Ernst, 2024; Fleischmann, 2025; Geßler, 2025; Schnickmann, 2025). Looking forward, we envision *search-query* growing through both community and academic contributions. The developer documentation provides guidance on extending the library, for example, adding support for new databases or custom linter rules. Our goal is to build an open platform and continually expand *search-query*'s capabilities in line with the needs of researchers working on literature review projects.

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