M5.3 – Final Evaluation

Juliane Stiller[1], Vivien Petras[1] & Andreas Lüschow[2]
[1]Humboldt-Universität zu Berlin
[2]Leibniz Institute for Psychology Information

– v1.0 –
September 2019

Abstract

This document presents the evaluation results from the CLUBS project. We describe the design of the evaluation experiment that allows us to compare the different systems that were developed. After presenting the outcomes (e.g., inter-annotator agreement) from a pilot experiment that was conducted before the final user evaluation, we give a detailed report about the different systems and their single evaluation results. The system that makes use of translated metadata performs best.

Contents

1 Introduction

The project developed different approaches for Cross-lingual Information Retrieval (CLIR) using the use case of the PubPsych portal, a multilingual search engine in the psychological domain. The goal of the project was to define the technical approaches that have a positive impact on information retrieval performance and are suitable to offer retrieval across languages. The approaches tested implemented the following CLIR techniques:

- query translation,
- content translation, and
- mapping of controlled vocabulary.

For evaluating the best approach and the performance of the best technique, we consider intrinsic and extrinsic evaluation (Fig. 1). A detailed description of the evaluation plan for all approaches can be found in the relevant project documentation [4].

Furthermore, the project documentation in [5] reports the single steps of the final retrieval performance test. The results of this final evaluation are detailed in the present report.

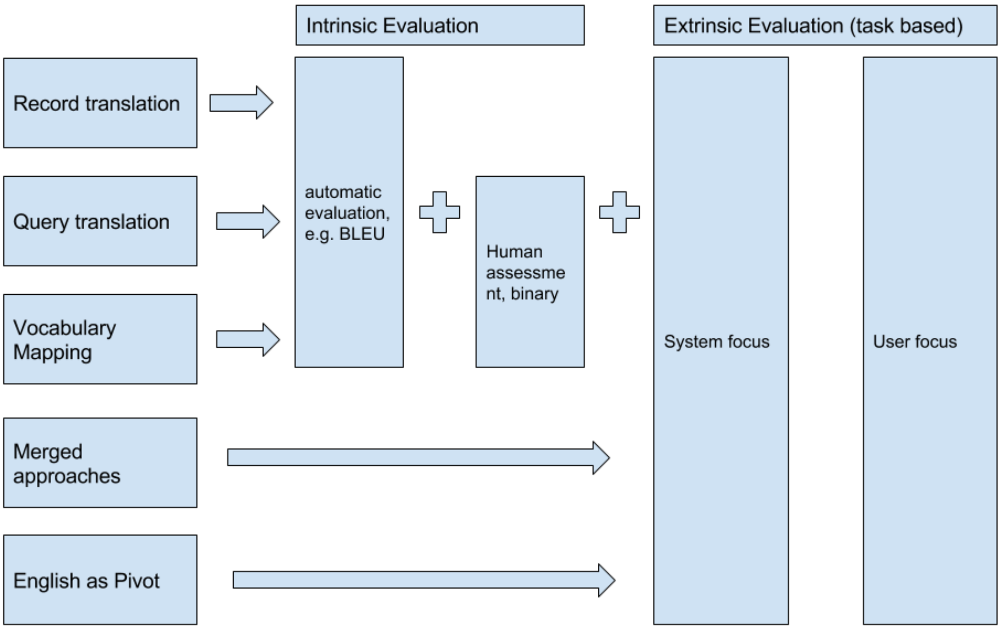


Figure 1: Plan for evaluation from the beginning of the project.

2 Design of Evaluation

2.1 Extrinsic system evaluation

The extrinsic system evaluation assesses which of the implemented techniques for CLIR has the most positive impact on retrieval performance. For that, different systems that implemented solutions for CLIR are assessed. They are compared against a given baseline and with each other.

2.2 Design of experiment

To compare different systems that implemented the developed approaches, we establish a baseline for retrieval. This baseline is created using a selection of 50 original queries that were actually sent to PubPsych by real users, and their human translations into 4 languages, leading to 200 original queries in total. We query our baseline system and store the top 10 results for each query (Fig. 2). Each other system is queried in the same way using these original queries. The systems have either content translation (i.e., machine translation of the search engine index) or real-time query translation implemented.

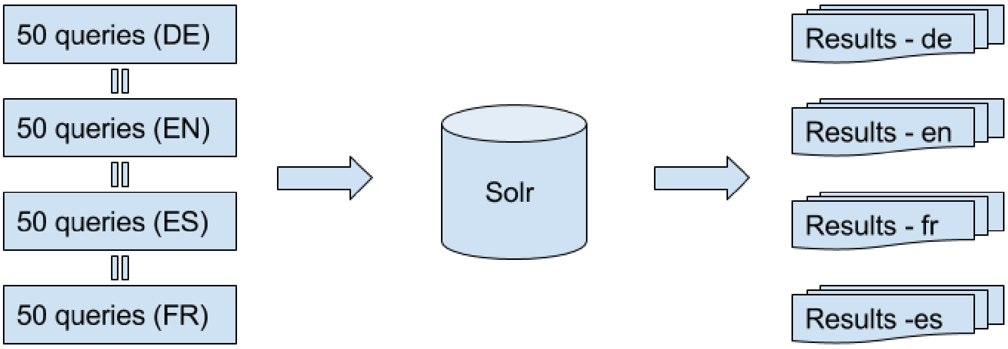


Figure 2: Retrieving 200 results lists from a PubPsych system with 50 queries in 4 languages.

For each document found, the relevance in relation to the retrieving query is assessed by human judges. For that, we use topic descriptions written by domain experts that make the information need of the single queries explicit to the judges. In each tested system, we store up to ten results for each of the 200 searches (4 x 50 queries). If a query results in less than 10 results, we store all results for this query.

After retrieving all documents, we remove duplicates (determined by the unique document ID and the topic they were retrieved with). The remaining documents are pooled by language of their metadata so they can be shown to a judge who understands this language. The judges assess the relevance of the document-query pairs on a three-point scale: highly, partially or non relevant. These relevance assessments allow us to compare results lists using the following measures (r is the total number of relevant documents in the index found for a given query; all measures are calculated separately for each query and thus result list):

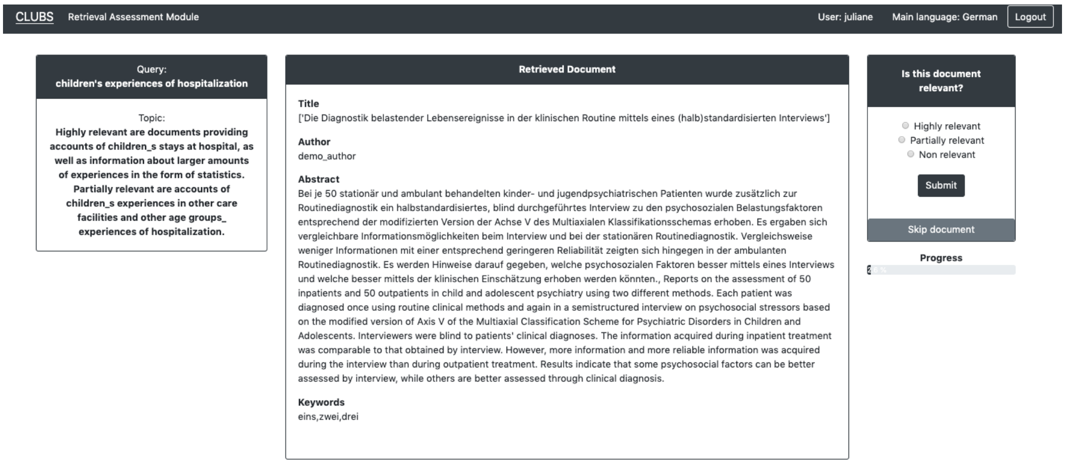
1. R-precision: If $r < 10$, we only look at the documents up to the r-th rank of the list. If $r >= 10$ then we calculate R-precision based on 10. In the latter case, values for R-precision and P@10 are identical.

2. P@10: We calculate the precision at 10 for the result list, i.e., the number of relevant documents on the first ten positions. As we only look at the first ten results, precision for the full result list will not be calculated separately.

3. Recall(10): How many of the relevant documents that exist for a query were actually found? If $r < 10$, recall is measured based on the actual number r. If $r >= 10$, the recall is measured based on $r = 10$ because only ten result documents will be looked at. In this case, Precision and Recall have identical values.

4. nDCG (normalized discounted cumulative gain): A rank-based measure. For this metric, the graded relevance (highly, partially, non relevant) of each document is important. Documents are weighted according to their graded relevance and their position on the result list. Hence, to achieve a high nDCG score, highly relevant documents must also occur high up in the ranked results lists.

The assessment of the document-query pairs is conducted using *CLUBS Compa*, a tool that was specifically developed during the project. Fig. 3 shows a screenshot of the tool with a document and its title, abstract, authors, and keywords in the middle of the screen. The retrieving query and the topic description are shown on the left side and the possible ratings judges can choose from on the right side. The tool has a user management system that automatically shows only those documents to a user which are written in the user's language. All ratings are saved in a database and can be exported for further analyses.



Query:
children's experiences of hospitalization

Topic:
Highly relevant are documents providing accounts of children_s stays at hospital, as well as information about larger amounts of experiences in the form of statistics. Partially relevant are accounts of children_s experiences in other care facilities and other age groups_ experiences of hospitalization.

Title
['Die Diagnostik belastender Lebensereignisse in der klinischen Routine mittels eines (halb)standardisierten Interviews']

Author
demo_author

Abstract
Bei je 50 stationär und ambulant behandelten kinder- und jugendpsychiatrischen Patienten wurde zusätzlich zur Routinediagnostik ein halbstandardisiertes, blind durchgeführtes Interview zu den psychosozialen Belastungsfaktoren entsprechend der modifizierten Version der Achse V des Multiaxialen Klassifikationsschemas erhoben. Es ergaben sich vergleichbare Informationsmöglichkeiten beim Interview und bei der stationären Routinediagnostik. Vergleichsweise weniger Informationen mit einer entsprechend geringeren Reliabilität zeigten sich hingegen in der ambulanten Routinediagnostik. Es werden Hinweise darauf gegeben, welche psychosozialen Faktoren besser mittels eines Interviews und welche besser mittels der klinischen Einschätzung erhoben werden könnten., Reports on the assessment of 50 inpatients and 50 outpatients in child and adolescent psychiatry using two different methods. Each patient was diagnosed once using routine clinical methods and again in a semistructured interview on psychosocial stressors based on the modified version of Axis V of the Multiaxial Classification Scheme for Psychiatric Disorders in Children and Adolescents. Interviewers were blind to patients' clinical diagnoses. The information acquired during inpatient treatment was comparable to that obtained by interview. However, more information and more reliable information was acquired during the interview than during outpatient treatment. Results indicate that some psychosocial factors can be better assessed by interview, while others are better assessed through clinical diagnosis.

Keywords
eins,zwei,drei

Figure 3: Tool used for rating the relevance of documents for a retrieving query.

3 Pilot Experiment

To test the experiment design as outlined above and in [5] and the assessment tool as well as the topic descriptions, a pilot evaluation is set up. As the retrieval experiment is in a multilingual environment, we want to test and collect data in this pilot experiment with regard to the following points:

- Get some mock first results.
- Estimate the time needed for the final evaluation.
- Identify problems with the topic descriptions.

- Which languages should the assessors speak? Do we need native speakers or can all assessors rate the English translations of the documents? To clarify this point, we calculate the inter-annotator agreement between different judges and see if the evaluation on the English translations of the documents is the same as the evaluation on the original documents. If the evaluation on English translations is as good as the evaluation on original content, we can only use English speaking assessors, which would probably be easier to acquire.
- Identify pain points that could be an issue for the real evaluation.
- Test the tool, its usability, database and document loading routine.

3.1 Experiment set-up

For the pilot assessment, we choose the set-up as outlined in Fig. 4. We use the 50 original queries in English to retrieve 100 documents in German, French and Spanish each. We extract these 300 documents from the results lists. We retrieve the same 300 documents in a system where the content was already translated into our four target languages to get these 300 documents also in English.

As a French native speaker could not be recruited, only the 100 German and the 100 Spanish documents are rated. The 300 translated documents are rated twice, once by the German and once by the Spanish rater. This set-up allows to compare the ratings of a judge rating native documents and rating their English translations (intra-annotator agreement) as well as the ratings of both judges rating the English documents (inter-annotator agreement).

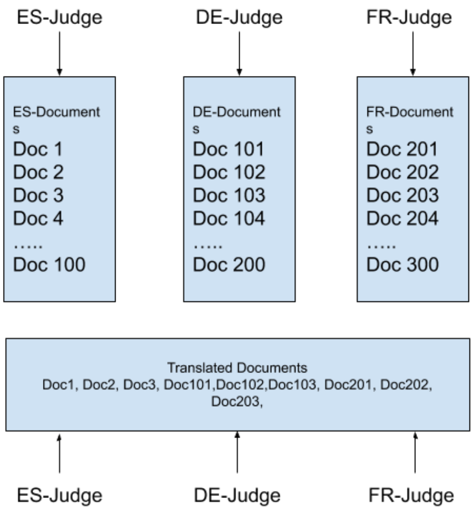


Figure 4: Experiment design for pilot evaluation with three judges. A French judge could not be recruited.

3.2 Results

In total, 500 different documents were rated. 300 of these documents (the English ones) were rated twice, their original counterparts in German and in Spanish were rated once by each judge. Table 1 shows the distribution of ratings for each rater. The ratings are not evenly distributed, there are far more ratings in the two *relevant* categories (highly, partially) than in the *non-relevant* category.

	Rating	# of documents
Rater ES	Highly relevant	207
	Partially relevant	127
	Non relevant	66
Rater DE	Highly relevant	212
	Partially relevant	114
	Non relevant	74

Table 1: Number of ratings per category and rater for 400 documents each.

3.2.1 Intra-annotator agreement

The intra-annotator agreement shows the agreement between a single assessor rating documents in the assessor's native language—in our case German (Table 2) or Spanish (Table 3)—and the same documents in their English translation.

		DE			
		Highly	Partially	Non	total
EN	Highly	43	11	0	54
	Partially	7	13	1	21
	Non	2	10	13	25
	total	52	34	14	100

Table 2: Rating matrix for the original German documents and their English translations rated by the same judge.

		ES			
		Highly	Partially	Non	total
EN	Highly	44	5	3	52
	Partially	4	25	3	32
	Non	2	4	10	16
	total	50	34	16	100

Table 3: Rating matrix for the original Spanish documents and their English translations rated by the same judge.

Of particular interest are the documents which were rated *non-relevant* in one result set but *highly relevant* in the other result set (German judge: 2 documents; Spanish judge:

2+3 documents). We analyze these documents to see if components of the experiment design need to be adapted.

Intra-annotator agreement for each rater can be found in Table 4. The measures are calculated for the rating of all three rating categories (highly, partially and non-relevant) as well as for only two categories where *highly* and *partially relevant* are considered to be a single *relevant* category.

	Rater DE		Rater ES	
	Cohen's Kappa	Scott's Pi	Cohen's Kappa	Scott's Pi
3 categories	0.494	0.488	0.653	0.653
2 categories	0.594	0.586	0.554	0.554

Table 4: Intra-annotator agreement for the German and Spanish assessor.

3.2.2 Inter-annotator agreement

Inter-annotator agreement measures the agreement of ratings of the German and the Spanish rater. These measures are shown in Table 5. Both Tables 4 and 5 show Cohen's Kappa and Scotts Pi. According to Landis and Koch [3], the kappa for all categories can be interpreted as ranging from fair (0.21–0.40) and moderate (0.41–0.60) to substantial (0.61–0.80) agreement. The same applies for Scott's Pi.

	Translations from Spanish		Translations from German	
	Cohen's Kappa	Scott's Pi	Cohen's Kappa	Scott's Pi
3 categories	0.556	0.554	0.502	0.494
2 categories	0.702	0.702	0.664	0.664

Table 5: Inter-annotator agreement between the German and Spanish assessor.

3.3 Limitation of experiment and learnings

For the pilot experiment, we were not able to recruit a native French speaker that can rate the relevance of French documents. Therefore, we could not gain data for this particular language. We also set out to assess the effect of machine translation on the assessment of documents. For our sample, we could not observe a difference in assessment.

The data is coming from the real-world database PubPsych which in its pure form is often bilingual, i.e., many documents already come with two or more languages in their metadata. Without a detailed language analysis of the metadata it is not possible to say for sure which languages are present in the data. For example, abstracts and titles are often translated by the source databases (e.g., Medline) that deliver their metadata to PubPsych and thus already copied into an index field (e.g., the title field). Attributing whether a particular rating was based on a machine translation or a manual translation was not feasible in practice.

Therefore, we decide to show judges in the final retrieval performance experiment as much information as possible: we extract the language-specific information for abstracts, titles and keywords as well as possible English translations that come from the source databases. We will use six judges, i.e., two for each language (German, French, Spanish), that are domain experts in the psychological domain. Every assessor should be able to rate English documents.

Furthermore, both raters in the pilot experiment were not domain experts and do not have a background in Psychology. We find that this aspect is crucial for the final experiment as the assessments are very dependent on the domain expertise of the judges. Additionally, the task of relevance assessment is extremely hard and strenuous due to topics such as abuse, violence, sicknesses covered, the domain vocabulary used, and the nature of the abstracts with their very compressed information.

In the pilot experiment, we were able to assess 50 documents per hour and expect this amount to be also feasible in the final experiment.[1]

4 Retrieval Assessment of CLIR Approaches

This section describes the results of the retrieval assessment of the different systems that implemented CLIR techniques. For evaluation, we compare three different systems with each other as well as their performance against the baseline (Fig. 5).

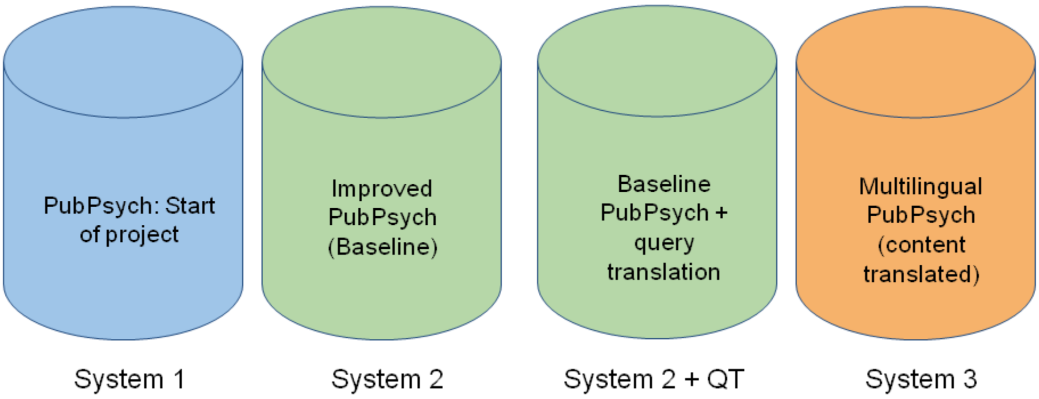

PubPsych: Start of project
Improved PubPsych (Baseline)
Baseline PubPsych + query translation
Multilingual PubPsych (content translated)
System 1
System 2
System 2 + QT
System 3

Figure 5: Comparison of different systems in retrieval assessment.

4.1 The different systems evaluated

The different systems that are evaluated:

- **System 1:** This system is the unaltered system at the start of the project. It can serve as baseline system with regard to measuring the impact the project has as a whole on the performance of the system.
- **System 2:** This is considered to be the baseline system. This is an error free system which we set up after cleaning up the database of System 1 and introducing some changes to the search engine index and ranking algorithm.

[1] For comparison, the assessment of pictures/short documents retrieved with queries in the cultural heritage domain is much faster. Raters can achieve numbers of up to 400 document assessments per hour.

- **System 2 with QT implemented:** This is the baseline system with an implementation of the query translation. All 200 queries (50 queries in 4 languages) are sent to this system and each query will be automatically expanded with translations into the other three languages.
- **System 3:** In this system, content in the PubPsych database is translated. Titles, abstracts and keywords are then available in English, German, French and Spanish. Thus, there is no need to additionally translate the query. All 200 original queries remain as they are.
- **System 3_old:** This system works the same as System 3. However, the content translation is not based on the final machine translation (MT) system but on an old MT system. This older system was used in the pilot experiment and thus also needs to be used in the final evaluation to query the English documents for calculating inter-annotator agreement between the six judges (see also the explanations in Section 3.2.2).

To compare different approaches—e.g., human translated queries in System 2 against machine translated queries in System 2—different *runs* are used to extract result lists from PubPsych. Table 6 shows all these runs. Please note that the number of documents in this table does only represent the amount of documents in a run that were not yet part of one of the previous runs (i.e., duplicates are removed because they do not need to be rated again). In total, 3,304 documents need to be rated by the assessors; plus 100 documents for each judge for comparing the inter-annotator agreement with the pilot experiment.

System	**Run name**	**Queries**	**Translation**	**# of docs**
System 1	HT_base	200 original	-	1259
System 2	HT_base8001	200 original	-	192
System 2	MT_from_DE_base8001	150 MT	Queries with DE as source	285
System 2	MT_from_FR_base8001	150 MT	Queries with FR as source	253
System 2	MT_from_ES_base8001	150 MT	Queries with ES as source	275
System 2	MT_from_EN_base8001	150 MT	Queries with EN as source	146
System 2 + QT	MT_combined_base8001	200 original	-	159
System 3	HT_content_trans	200 original	content	735
System 3_old	pilot_run	-	-	100

Table 6: Overview of systems, runs and retrieved documents that need to be rated, excluding duplicates. MT = machine translated queries, HT = human translated (i.e., original) queries.

4.2 System-focused evaluation

The following subsections illustrate the compostition of result lists of the different runs. For each language the queries that retrieved results (i.e., result list length > 0), the number of total retrieved documents, the number of retrieved documents in the top ten positions of the result ranking and the mean of retrieved documents is demonstrated.

4.2.1 The baseline

HT_base. In the baseline there are 1,490 documents that need to be rated. Overall, the 50 queries in English, German, French and Spanish found 121,765 documents.

	DE	EN	ES	FR
Queries that retrieved results	43	50	41	42
Retrieved documents	24,185	71,990	3,828	21,762
Retrieved docs top ten	366	500	277	347
Mean of retrieved document (n=50)	483.70	1439.80	76.56	435.24

HT_base8001. Overall, the 200 original queries retrieved 118,978 documents. In the top ten results, 1,477 documents were retrieved.

	DE	EN	ES	FR
Queries that retrieved results	42	50	38	42
Retrieved documents	23,714	69,971	3,817	21,476
Retrieved docs top ten	353	500	277	347
Mean of retrieved document (n=50)	474.28	1399.42	76.34	429.52

4.2.2 Machine translated queries

MT_from_EN_base8001. Overall, the 150 from English translated queries retrieved 49,813 documents. In the top ten results, 799 documents were retrieved.

	DE	ES	FR
Queries that retrieved results	35	29	39
Retrieved documents	16,540	5,674	27,599
Retrieved docs top ten	262	211	326
Mean of retrieved document (n=50)	330.80	113.48	551.98

MT_from_DE_base8001. Overall, the 150 from German translated queries retrieved 79,273 documents. In the top ten results, 852 documents were retrieved.

	EN	**ES**	**FR**
Queries that retrieved results	39	28	33
Retrieved documents	53,919	9,040	16,314
Retrieved docs top ten	364	210	278
Mean of retrieved document (n=50)	1078.38	180.80	326.28

MT_from_FR_base8001. Overall, the 150 from French translated queries retrieved 62,631 documents. In the top ten results, 733 documents were retrieved.

	DE	**EN**	**ES**
Queries that retrieved results	25	37	26
Retrieved documents	12,789	44,992	4,850
Retrieved docs top ten	207	328	198
Mean of retrieved document (n=50)	255.78	899.84	97.0

MT_from_ES_base8001. Overall, the 150 from Spanish translated queries retrieved 115,097 documents. In the top ten results, 767 documents were retrieved.

	DE	**EN**	**FR**
Queries that retrieved results	24	37	32
Retrieved documents	25,731	51,228	38,138
Retrieved docs top ten	199	309	259
Mean of retrieved document (n=50)	514.62	1024.56	762.76

4.2.3 Automatic query translation

MT_combined_base8001. Overall, the 200 original queries retrieved 964,975 documents. In the top ten results, 1,635 documents were retrieved.

	DE	EN	ES	FR
Queries that retrieved results	46	50	43	46
Retrieved documents	265,219	427,708	87,941	184,107
Retrieved docs top ten	392	500	350	393
Mean of retrieved document (n=50)	5304.38	8554.16	1758.82	3682.14

4.2.4 Content translation

HT_content_trans. Overall, the 200 original queries retrieved 386,465 documents. In the top ten results, 1,910 documents were retrieved.

	DE	EN	ES	FR
Queries that retrieved results	47	50	48	50
Retrieved documents	63,862	142,070	80,415	100,118
Retrieved docs top ten	444	500	467	499
Mean of retrieved document (n=50)	1277.24	2841.40	1608.30	2002.36

4.2.5 Interpretation

The tables above allow for some further evaluation of the performance of the different systems. Table 7 gives an overview of the comparisons we can do with the different runs.

Run A	Run B	Purpose
HT_base	HT_base8001	The effect of changes to the system (start of project) to improvements
HT_base8001	MT_from_XX_base8001	Effect of Machine Translation on Retrieval: does a human translated query produce better results than the MT one?
HT_base8001	HT_content_trans	Effect of content translation on retrieval compared to baseline
HT_base8001	MT_combined_base8001	Effect of query translation on retrieval compared to baseline
MT_combined_base8001	HT_content_trans	Compare query vs. content translation

Table 7: Possible comparisons with the different runs.

- HT_base vs. HT_base8001: The latter does not find as much documents as the other one. Additionally, there are 4 more queries that do not find documents at all in the baseline system. This does not necessarily mean that the baseline system performs worse than before the start of the project—it is probable that the original system had some indexing and ranking errors that led to the retrieval of irrelevant documents. However, this assumption needs to be proven with the final evaluation metrics (see section 4.3).

- HT_base8001 vs. MT_from_XX_base8001: All runs in which the queries were automatically translated from one of the four languages perform worse than the baseline system which uses human translated queries. They do by far not retrieve as much documents as the original queries and the number of queries with zero results increases notably.

- HT_base8001 vs. HT_content_trans: The system with content translation retrieves more than three times as much documents than the baseline system (118,978 vs. 386,465). The number of queries with a zero result list length decreases from 28 to 5. The amount of retrieved German documents is more than twice as high (23,714 vs. 63,862), the amount of French documents is four times as high (21,476 vs. 100,118) and the number of Spanish documents increases by a factor of 21 (3,817 vs. 80,415). Even for the English language, the number of retrieved documents doubles (69,971 vs. 142,070).

- HT_base8001 vs. MT_combined_base8001: In the system that implemented real-time query translation, the amount of queries with zero length result lists also decreases (from 28 to 15), but not as much as with System 3. Furthermore, there seem to be some queries with a lot of retrieved documents but also many queries that lead to a result list with less than ten entries, because the number of retrieved documents in the top ten positions is not as near to 500 (the optimal number) as in System 3.

- MT_combined_base8001 vs. HT_content_trans: The comparison of these two systems can be deviated from the two previous paragraphs.

Table 12 (Appendix) shows the number of retrieved top ten documents per system, grouped by different document and query languages. The data illustrates that, although retrieving more documents in total, System 2 with online query translation does not perform better than System 3 which retrieves the most documents for most of the languages.

It is worth noticing that System 2 with query translation seems to perform best when it comes to Spanish metadata, retrieving considerably more documents in this language than the other approaches (except in those cases where Spanish is already the language of the query). Documents in the same language as the query are the most retrieved with the two baseline systems. This fact indicates that all other systems include more documents in their result lists that do not have the same language as the query, i.e., that the cross-lingual retrieval works.

Table 13 (Appendix) summarizes the main insights from the system-focused evaluation and allows for a direct comparison of the outocmes from the different approaches.

4.3 User-focused evaluation

The relevance of all found documents was rated by the six judges. This allows us to calculate the metrics as described in Section 2.2. Since all 50 queries lead to more than 10 relevant results ($r = 10$), Precision@10, Recall and R-precision have identical values.

Table 8 shows the retrieval performance for the machine translated queries used in System 2. All measures are lower than those for the baseline system, which underlines the observations made during the system-focused evaluation. The baseline system and the other approaches are illustrated in Table 9.

The system performing best is System 3 which uses content translation and no query translation. System 2 (the baseline) does not perform better that System 1 before the start of the project. This reveals that the changes to the index and ranking algorithm we implemented at the beginning of the project had no effect on the retrieval performance.

	MT from DE	**MT from EN**	**MT from FR**	**MT from ES**
R-Precision	**0.637**	0.519	0.570	0.566
P@10	**0.637**	0.519	0.570	0.566
Recall(10)	**0.637**	0.519	0.570	0.566
nDCG	**0.565**	0.504	0.497	0.554

Table 8: Comparison of machine translations – retrieval performance

	System 1 (initial system)	**System 2 (improved system)**	**System 2 + QT**	**System 3**
R-Precision	0.660	0.651	0.714	**0.830**
P@10	0.660	0.651	0.714	**0.830**
Recall(10)	0.660	0.651	0.714	**0.830**
nDCG	0.569	0.567	0.606	**0.702**

Table 9: Comparison of all systems – retrieval performance

However, they were necessary to prepare the software for being able to implement Systems 2 and 3.

Compared to the baseline, System 2 with online query translation leads to an appreciable improvement in retrieval quality. However, System 3 shows the best scores and in combination with the analysis in the previous section, this system is the clear winner of the evaluation.

4.4 Inter-annotator agreement

We calculated the inter-annotator agreement between the six judges using the same documents as in the pilot experiment. Results are presented in Tables 10 and 11.

Some judges achieve a moderate agreement (0.41–0.60), most agreements are fair (0.21–0.40). Especially one of the Spanish assessors has rather bad agreements with the other judges. This may indicate a systematic error that was introduced into the experiment.

5 Discussion

In this section, we discuss the results of the previously described final project evaluation.

5.1 System 2

The baseline system with improved algorithm and indexing does overall perform equivalent to System 1 without adaptations. Most of the improvements were however necessary to make the search engine software more adaptable and to update the source code, so that the different implementations for this project could be integrated into the PubPsych system.

As Table 12 shows, documents in the same language as the query are the most retrieved with the two baseline systems. This indicates that the implementations during the

	Rating	# of documents
Rater DE 1	Highly relevant	66
	Partially relevant	24
	Non relevant	10
Rater DE 2	Highly relevant	60
	Partially relevant	28
	Non relevant	12
Rater FR 1	Highly relevant	58
	Partially relevant	28
	Non relevant	14
Rater FR 2	Highly relevant	41
	Partially relevant	37
	Non relevant	22
Rater ES 1	Highly relevant	67
	Partially relevant	29
	Non relevant	4
Rater ES 2	Highly relevant	62
	Partially relevant	23
	Non relevant	15

Table 10: Number of ratings per category and assessor for 100 documents each.

CLUBS project indeed improved multilingual retrieval, because more documents in other languages than the query language are retrieved in these systems. However, it needs to be examined to which extent such a ”replacement” of documents in query language in favour of multilingual content is accepted by search engine users. If they retrieve a document whose metadata is translated but where they can not read the original document, such a document may be considered irrelevant even if the ranking algorithm places it at the top of the result list.

5.2 System 2 with query translation

This system performs better than the baselines but not as good as the winning approach, System 3, albeit it retrieves a lot of documents that do not seem to be relevant. In fact, some of the queries generate very large result lists whereas other queries do not find anything at all. This is probably due to the online query translation that looks up words from the search query in a multilingual lexicon.

If a query can not be found in this lexicon, its single words (tokens) are looked up in the dictionary.[2] Obviously, this leads to translations that are quite general and thus retrieve many documents. Additionally, the combination of search terms using the Boolean OR operator enlarges the number of potentially relevant documents. If one of the search terms is a preposition such as ”of”, ”in” or ”at”, a translation of this term into three other languages also dilates the search result list. This may explain the high number of documents found with this approach.

[2] For more information on how the online query translation approach works, see also the project documentation in [1] and the relevant CLUBS article from MTSR 2018 conference [2].

	DE 2	FR 1	FR 2	ES 1	ES 2
DE 1	0.524	0.384	0.305	0.318	0.539
DE 2	-	0.389	0.343	0.102	0.450
FR 1	-	-	0.347	0.161	0.369
FR 2	-	-	-	0.130	0.347
ES 1	-	-	-	-	0.199

(a) Cohen's Kappa, 3 categories

	DE 2	FR 1	FR 2	ES 1	ES 2
DE 1	0.522	0.382	0.277	0.316	0.538
DE 2	-	0.389	0.328	0.097	0.449
FR 1	-	-	0.335	0.154	0.368
FR 2	-	-	-	0.090	0.328
ES 1	-	-	-	-	0.192

(b) Scott's Pi, 3 categories

	DE 2	FR 1	FR 2	ES 1	ES 2
DE 1	0.592	0.434	0.275	0.242	0.591
DE 2	-	0.293	0.443	0.202	0.615
FR 1	-	-	0.397	0.171	0.395
FR 2	-	-	-	0.175	0.507
ES 1	-	-	-	-	0.157

(c) Cohen's Kappa, 2 categories

	DE 2	FR 1	FR 2	ES 1	ES 2
DE 1	0.591	0.432	0.256	0.232	0.589
DE 2	-	0.293	0.433	0.185	0.615
FR 1	-	-	0.390	0.145	0.395
FR 2	-	-	-	0.116	0.503
ES 1	-	-	-	-	0.128

(d) Scott's Pi, 2 categories

Table 11: Inter-annotator agreement in the final evaluation.

5.3 System 3

This is the winner system. Both the system-focused evaluation of the result lists and the user-focused evaluation (i.e., relevance ratings) show a clear preference for this approach. This system will be integrated into PubPsych's live system and allows future users to make use of the cross-lingual features that were developed and evaluated during this project.

As a next step, it will be necessary to implement the machine translation pipeline into PubPsych's indexing workflow to be able to translate document metadata as soon as it enters the index. The required scripts and translation models were developed during the project and can be reused.

References

[1] Cristina España-Bonet and Roland Ramthun. M1.5 — Mapping Approaches for Vocabularies and Queries in PubPsych. Technical report, CLUBS-Project, March 2018.

[2] Cristina España-Bonet, Juliane Stiller, Roland Ramthun, Josef van Genabith, and Vivien Petras. Query Translation for Cross-lingual Search in the Academic Search Engine PubPsych. In *Proceedings of the 12th International Conference on Metadata*

and Semantics Research, MTSR 2018, Communications in Computer and Information Science, vol. 846, pages 37–49, 2018.

[3] J. Richard Landis and Gary G. Koch. The Measurement of Observer Agreement for Categorical Data. *Biometrics*, 33(1):159–174, 1977.

[4] Juliane Stiller and Vivien Petras. M1.3.1 – Evaluation plan for CLUBS project. Technical report, CLUBS-Project, July 2017.

[5] Juliane Stiller and Vivien Petras. M1.3.2 – CLUBS. Testing retrieval performance. Technical report, CLUBS-Project, March 2018.

A Additional Tables

Query language	Document language	System 1	System 2	System 2 with QT	System 3
DE	English	75	65	96	**172**
	French	4	4	**18**	11
	German	**284**	280	215	254
	Spanish	2	4	**63**	5
	Missing / other	1	0	0	2
EN	English	393	**414**	283	351
	French	9	9	**35**	16
	German	94	68	81	**117**
	Spanish	2	4	**94**	10
	Missing / other	2	5	7	6
FR	English	147	153	178	**300**
	French	**157**	155	103	110
	German	39	34	43	**73**
	Spanish	1	3	**67**	11
	Missing / other	3	2	2	5
ES	English	80	81	134	**225**
	French	4	3	19	**22**
	German	27	19	39	**55**
	Spanish	161	**169**	152	158
	Missing / other	5	5	6	7

Table 12: Retrieved document languages in the four systems, grouped by query language.

	System 1 (initial system)	**System 2 (improved system)**	**System 2 + QT**	**System 3**
# of queries with 0 results out of 200	24	28	15	5
Sum of found documents for queries	121,765	118,978	964,975	386,465

Per language DE / EN / ES / FR	De = 24,185
	En = 71,990
	Es = 3,828
	Fr = 21,762
		De = 23,714
		En = 69,971
		Es = 3,817
		Fr = 21,476
			De = 265,219
			En = 427,708
			Es = 87,941
			Fr = 184,107
				De = 63,862
				En = 142,070
				Es = 80,415
				Fr = 100,118

# of documents in top ten	1,490	1,477	1,635	1,910

Mean of retrieved documents across queries (n=50) per language	De = 483.70
	En = 1439.80
	ES = 76.56
	Fr = 435.24
		De = 474.28
		En = 1399.42
		ES = 76.34
		Fr = 429.52
			De = 5304.38
			En = 8554.16
			Es = 1758.82
			Fr = 3682.14
				De = 1277.24
				En = 2841.40
				Es = 1608.30
				Fr = 2002.36

Table 13: Comparison of all systems – describing statistics.