Semantic and Pragmatic Properties of LLM's "Hallucinations" in the Medical Field

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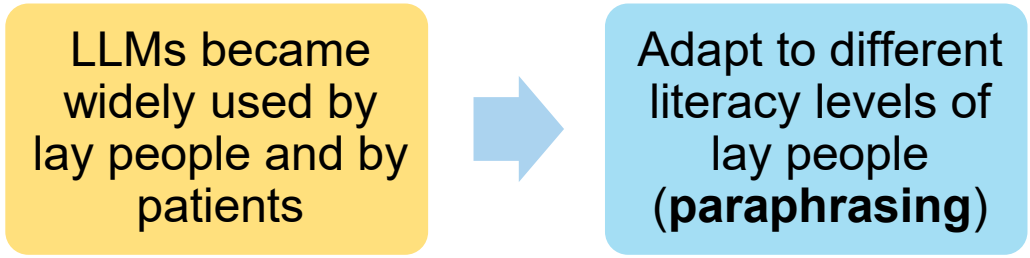
1. Context of the Study: LLMs in the Medical Field (I)



- **Medical paraphrases** = explain and simplify medical terms and make medical knowledge accessible to lay people (Grabar & Hamon, 2015; Buhnila, 2022)

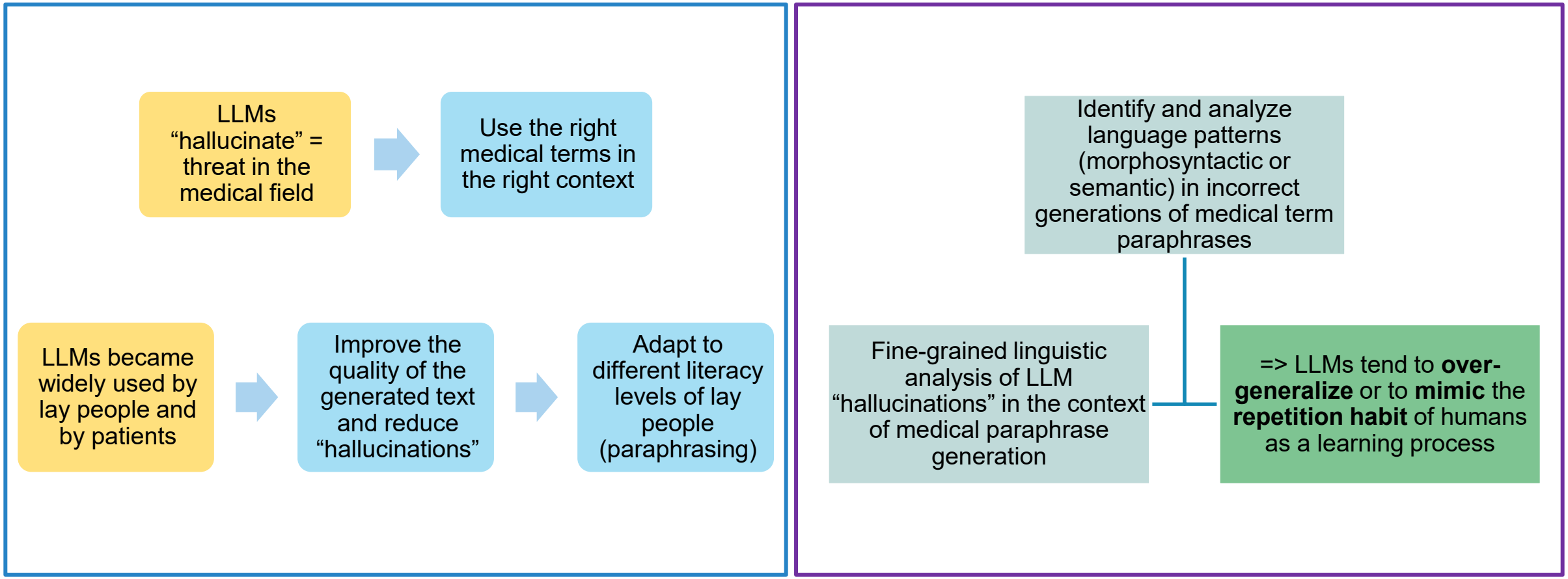
  Examples:

  [1] *placebo* (placebo) – *faux médicament* (fake medicine)

  [2] *hypotension* (hypotension) – *faible tension arterielle* (low blood pressure)

- **Simplified medical** content can also facilitate communication with patients (Pecout et al., 2019; Koptient & Grabar, 2020)

1. Context of the Study: Motivation and Goals (II)



1. Context of the Study: Resource Overview (III)

Paraphrase Dataset	Corpora	Type	Tokens	Sentences with terms and paraphrases	Tokens	Sentences with correct paraphrases
RefoMed **(Buhnila, 2023)**	**ClassYN** (Todirascu et al., 2012)	Scientific	1 007 049	**2 689**	**88 407**	**1 195**
		Popularization	772 374	**4 871**	**139 320**	**2 234**
	CLEAR Cochrane (Grabar et Cardon, 2018)	Scientific	2 840 003	**4 687**	**173 616**	**2 528**
		Popularization	1 515 051	**3 980**	**123 249**	**2 669**
	Total		***6 134 477***	***16 227***	***524 592***	***8 626***

1. Context of the Study: Data (IV)

- 2266 paraphrases generated for 480 terms

Generated Paraphrases	Correct Paraphrases	Incorrect Paraphrases	Partially correct *	Repetitions**	No Tag ***	Abbreviations****
2266 (100%)	725 (31,99 %)	779 (34,38 %)	211 (9,31 %)	5 (0,22 %)	545 (24,05 %)	1 (0,05 %)

* **Invented words**: *l'oxyde d'oxalate* (oxylate oxyde)

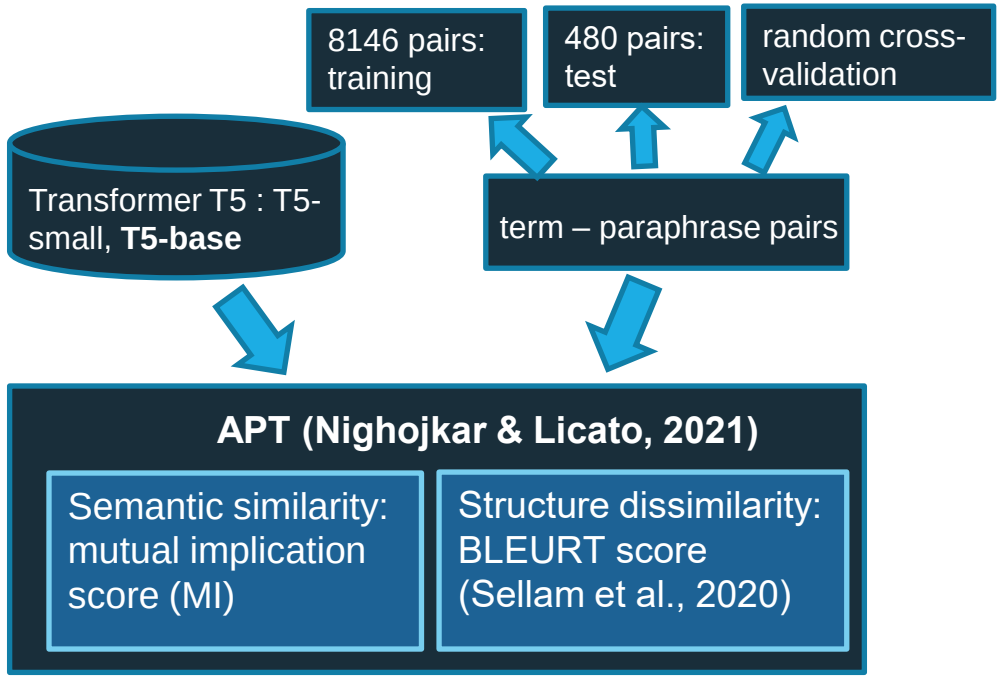
** **Repeated words**: *maladie maladie de Parkinson* (Parkinson disease disease)

*** **Abbreviations excluded from the linguistic annotation**: *médecine traditionnelle chinoise (MCT)* (traditional chinese medicine (TCM))

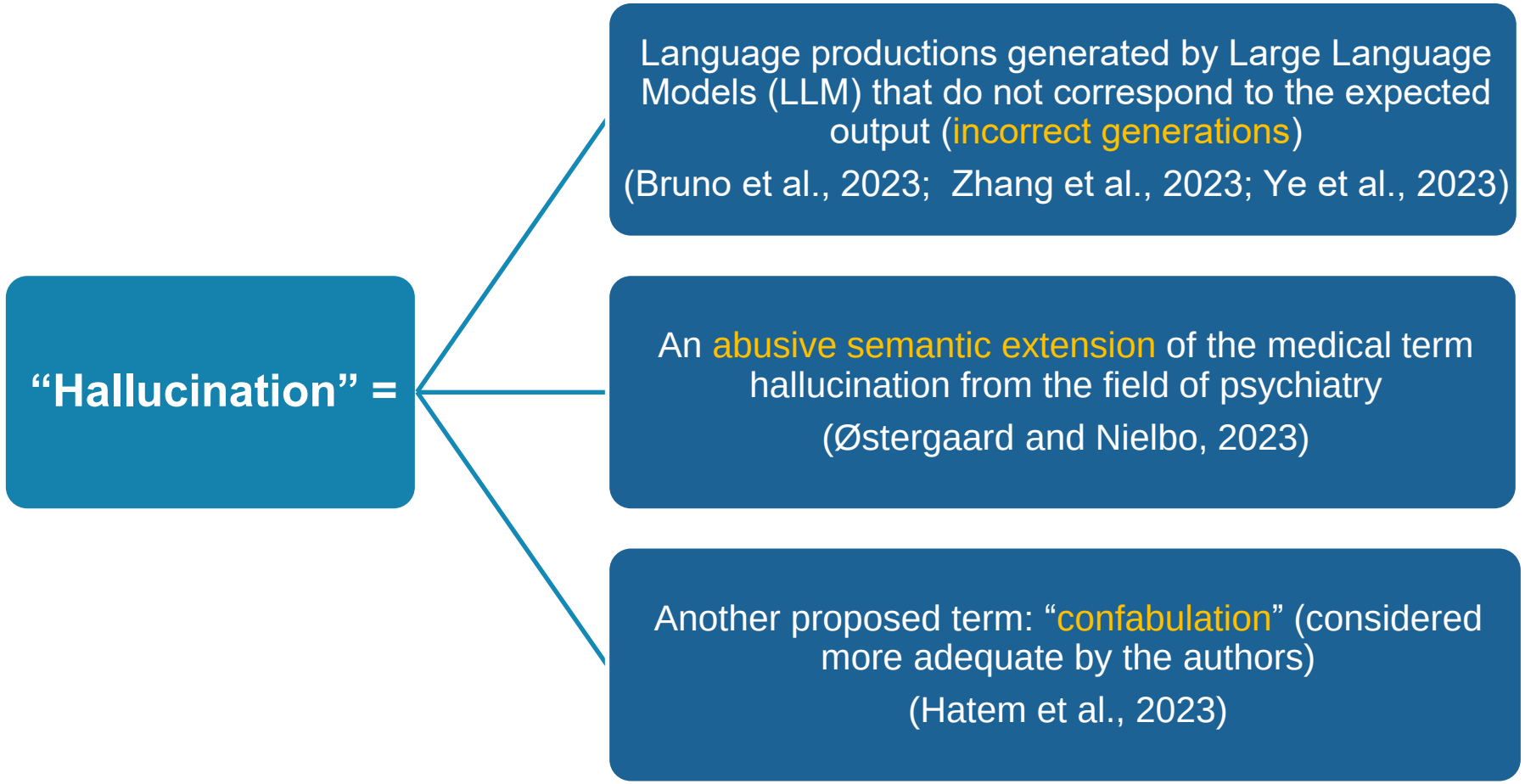
**** **Resting abbreviations**

1. Context of the Study: NLP Task and Tools (V)

- **NLP Task : Paraphrase Generation (PG) :** create new texts from data and LLMs (Gupta et al., 2018 ; Bowman et al., 2016).
  - **APT architecture** (*Adversarial Paraphrasing Task*) (Nighojkar & Licato, 2021)
  - **Transformer T5 LLM** (*Text-to-Text Transformer*) (Raffel et al., 2020)



2. LLMs' "Hallucinations": Definition and Concept Discussion (I)



2. LLMs "Hallucinations" (II)

[1] **Term**: *acetylcholine* (acetylcholine)

Correct paraphrase: *connue sous le nom de substance chimique* (known as a chemical substance)

"Hallucination": *c'est-à-dire l'oxyde d'oxalate de glycosyle de l'oxalate* (i.e. the glycosyl oxalate oxide of the oxalate)

[2] **Term**: *strabisme* (strabismus)

Correct paraphrase: *est une affection dans laquelle les yeux ne sont pas alignés normalement* (is a condition in which the eyes are not aligned normally)

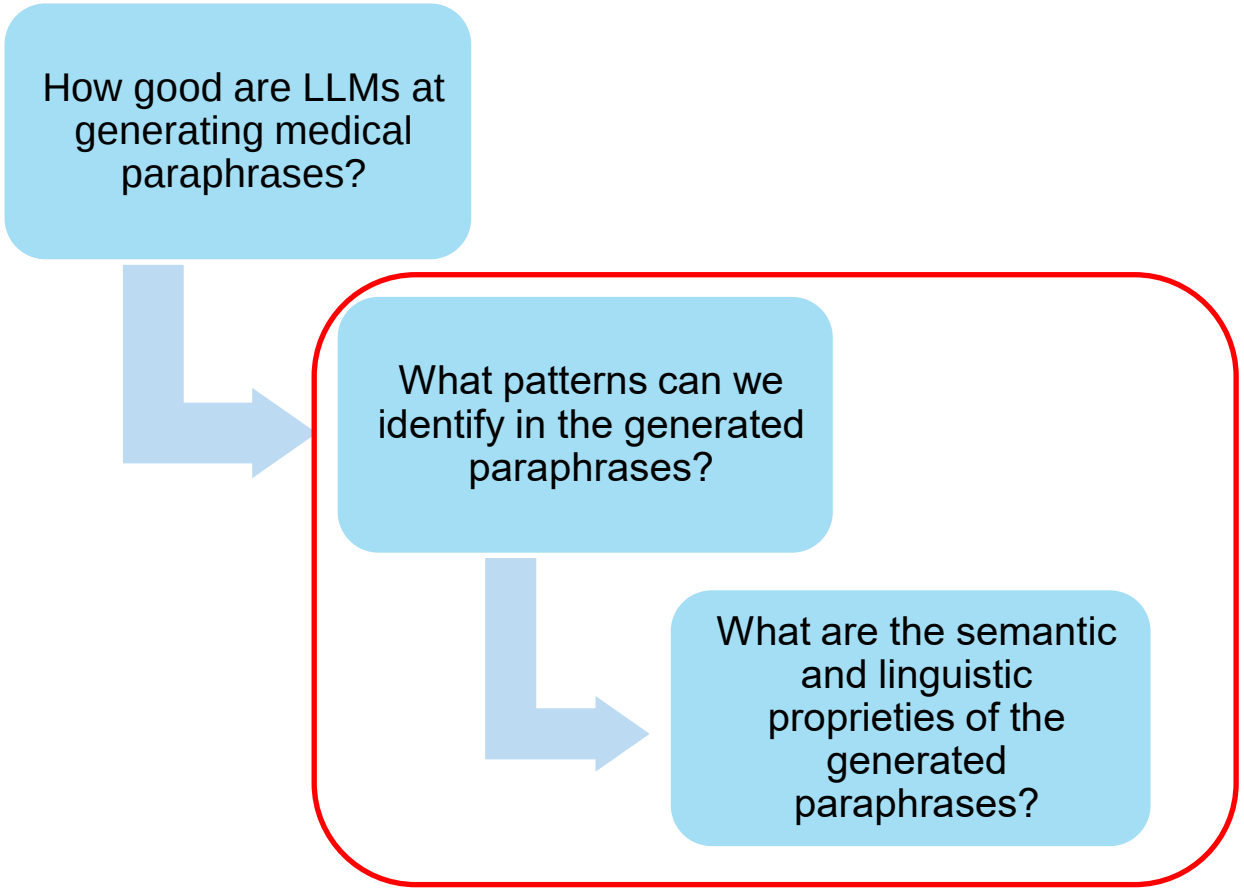
"Hallucination": *est une maladie associée à une stagiaire ayant tendance à se dissoudre rapidement* (is a condition associated with a trainee with a tendency to dissolve rapidly)

[3] **Term**: *sepsis* (sepsis)

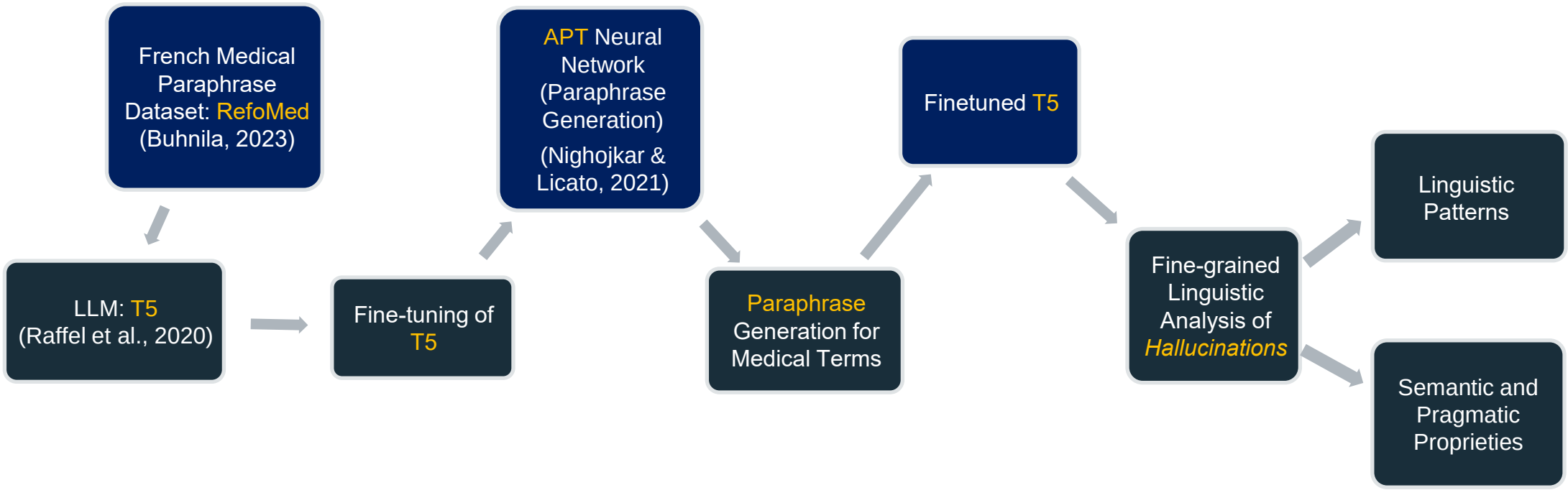
Correct paraphrase: *infection du pied diabétique* (diabetic foot infection)

"Hallucination": *une maladie neurodégénérative courante* (a common neurodegenerative disease)

3. Primary Research Questions



4. Method (I)


French Medical Paraphrase Dataset: RefoMed (Buhnila, 2023)
LLM: T5 (Raffel et al., 2020)
Fine-tuning of T5
APT Neural Network (Paraphrase Generation) (Nighojkar & Licato, 2021)
Paraphrase Generation for Medical Terms
Finetuned T5
Fine-grained Linguistic Analysis of Hallucinations
Linguistic Patterns
Semantic and Pragmatic Proprieties

4. Fine-grained Lingusitic Analysis (II)

- **Quantitative annotation of "hallucinations"**:
  - **Annotation of grammaticality**: correct, incorrect or partially correct;
  - **Type of inadequacy**: incorrect form, but comprehensible; correct form but not equivalent meaning; incorrect meaning;
  - **Lexical relations***: hyperonymy, hyponymy, synonymy, meronymy* (Sapoiu, 2013) (ex. [3]);
  - **Semantic-pragmatic functions:** *definition, exemplification, rephrasing, explanation* (Eshkol-Taravella & Grabar, 2017; Buhnila, 2022);

- **Quantitative analyses of "hallucinations"**:
  - **Degree of grammatical and semantic adequacy** of the generated text: invented words, genre/number mistakes, morphosyntaxctic errors (ex. [1] & [2]) ;
  - **Combinatorial discrepancies:** association of incompatible or foreign terms, mixture of different morphemes in invented words (ex. [1]).

5. Analysis Results (I)

- “Hallucinations” show:
  - incorrect medical knowledge (ex. [4])

[4] **Term**: *myopie* (myopia)

Correct paraphrase: *est un défaut de la vision qui se trouble lorsque des objets sont observés à distance* (is a vision defect that becomes blurred when objects are viewed from a distance)

“Hallucination” : *tel que un sombre myocarde* (such as a dark myocardium)

  - aberrant information (ex. [5])

[5] **Term**: *médecine traditionnelle chinoise* (traditional chinese medicine)

Correct paraphrase: c'est-à-dire une ancienne méthode chinoise (meaning an old chinese method)

“Hallucination” : *c'est-à-dire les méthodes d'admission orales dans les écoles ou les foyers de l'école, par exemple* (meaning oral admission methods into schools or school fosters, for example)

5. Analysis Results (II)

- “Hallucinations” show similarities with the exploitation of **patterns** in natural language practice:
  - Abusive **generalizations** of patterns not validated by usage (hypernyms and hyponyms)
  - Comparable processes to **foreign language learning** (rephrasing and definitions)
  - **Frequency calculations** in the absence of contextualized statistical weights (Piantadosi (2014), Zipf law).
  - Abusive use of **repetition** as a truth effect (Hasher et al., 1977; Dechêne et al., 2010)

5. The Place of Intention in LLMs' Paraphrases (III)

- LLMs are often antropomorphized and associated with an **"illusion of content"** (Ostertag, 2023)
- However, LLMs are **obeying rules** and **not communicative intentions** (while humans respond to both)
- Yet LLMs are oriented towards **intention recognition** (Manias et al., 2024)
- Good calculation of user's intentions may not prevent the generation of "confabulations" or non-appropriate paraphrases
- No specific meaning can be inferred, only **patterns** can be identified
- Intentions ≠ Pattern reproduction ≠ Meaning
- In return, this also questions the place of **pattern reproduction in human languages**

6. Conclusion and Future Work

Computer sciences: "hallucinations" raise questions about the right language model parameters for text generation

Linguistics: linguistic usages of patterns in human language and their reproduction by generative LLMs

Solutions? **RAG** systems for scientific grounding

(Lewis et al., 2020; Asai et al., 2023; Jeong et al., 2024)

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Thank you for your attention !