CNRS - Concours chercheurs 2025
CR Section 53 - Concours n° 53/03

Épistémologie des modèles distributionnels de langage par apprentissage machine

Explicabilité formelle et interprétabilité théorique

Juan Luis Gastaldi

`http://www.jlgastaldi.com/assets/gastaldi_cnrs_cr.pdf`

ETH zürich

12 Mai 2025

Parcours

1997-2007 Recherche pré-doctorale
Sciences Po, Philosophie, Maths
Argentine, France
(UNR, ENS, Paris 1, UPMC)

2008-2014 Recherche doctorale
Philo et Hist des Sciences
France
(Bordeaux Montaigne)

2015-2022 Professeur d'Ens. Artistique
Philo et Hist des Idées
France
(MO.CO.ESBA)

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Philo et Informatique
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2023-Présent Nouvelle recherche doctorale
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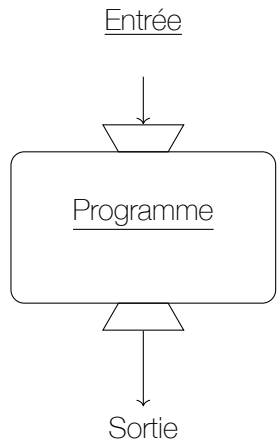
Recherche

- **Formalisme critique**: Alliance entre les humanités critiques et les sciences formelles
- Approche **philosophique**, **historique**, **théorique** et **technique**
- Thèse en Philosophie: Philosophie et histoire de la **mathématisation de la logique** (Gastaldi, 2014)
- Thèse en Informatique: **Tokenisation en TAL** (Gastaldi et al., 2024; Giulianelli et al., 2024; Vieira et al., 2024; Zouhar et al., 2023a, 2023b)

La structure implicite des données



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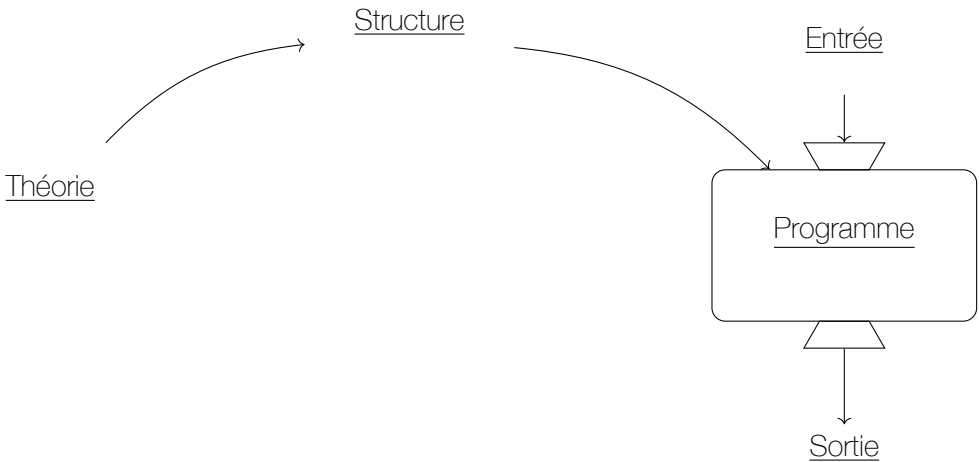

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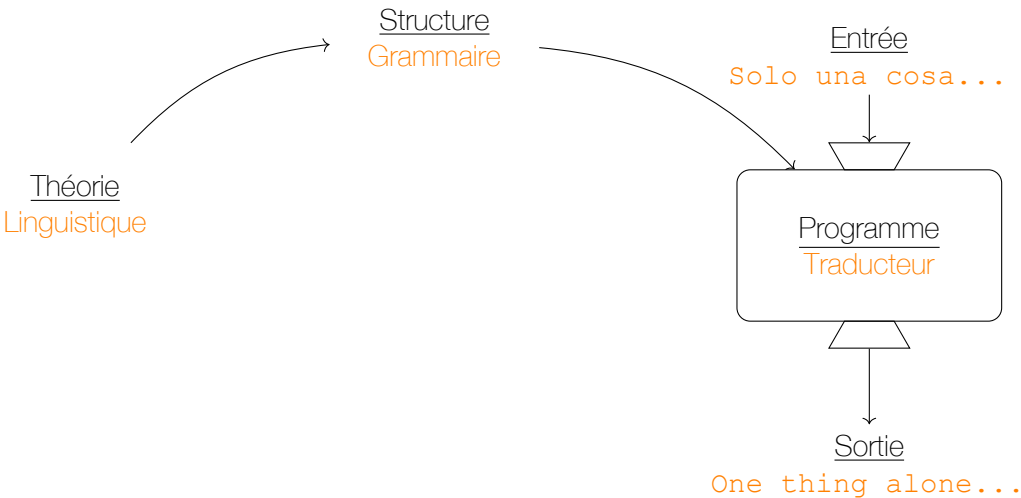
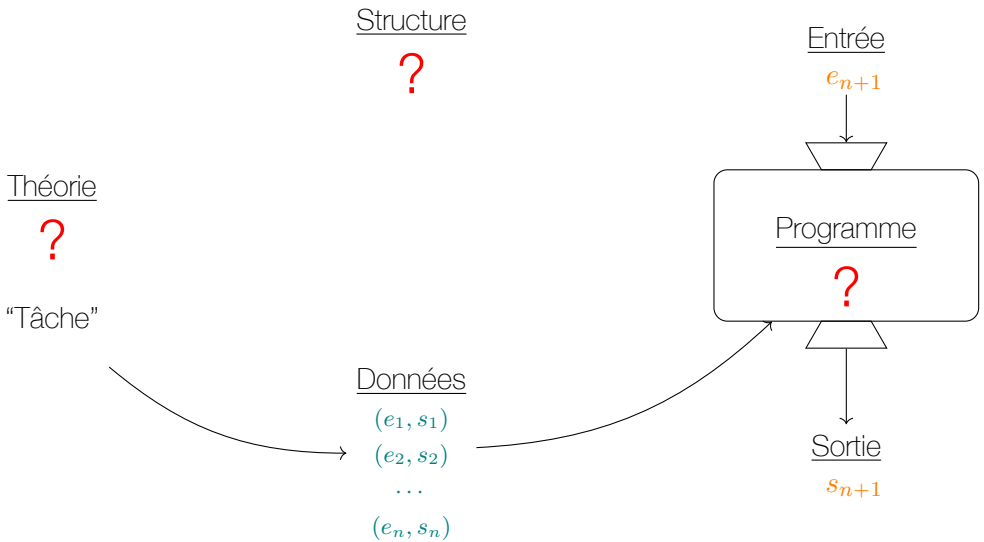
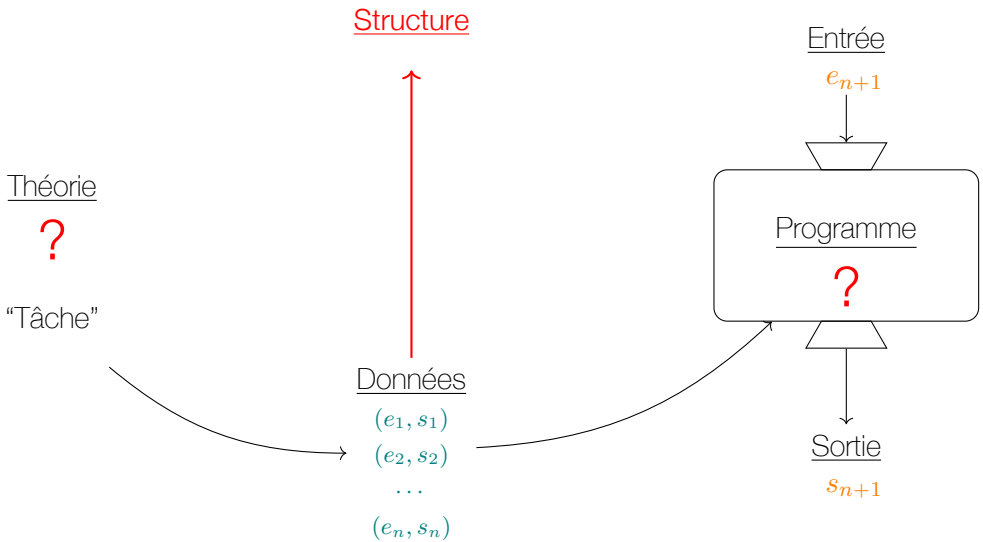


La structure implicite des données



La structure implicite des données



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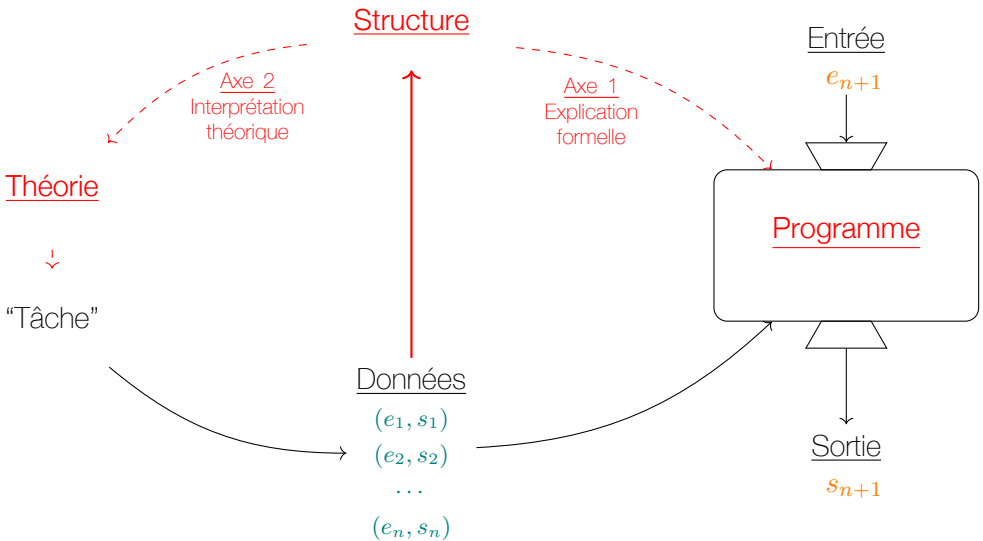
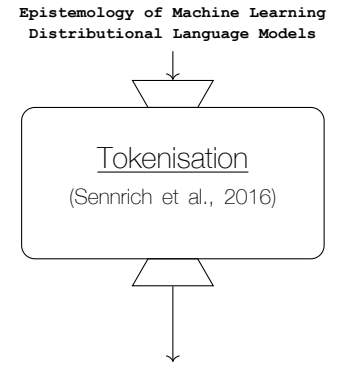


Axe 1: Explicabilité formelle



(https://tiktokenizer.vercel.app)

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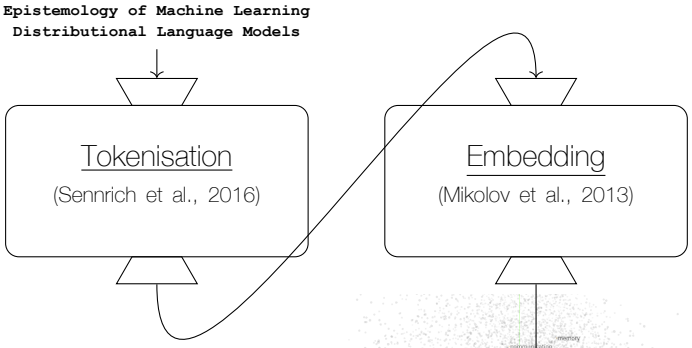
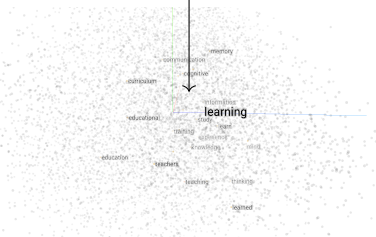


Epistemology of Machine Learning
Distributional Language Models

(https://tiktokenizer.vercel.app)



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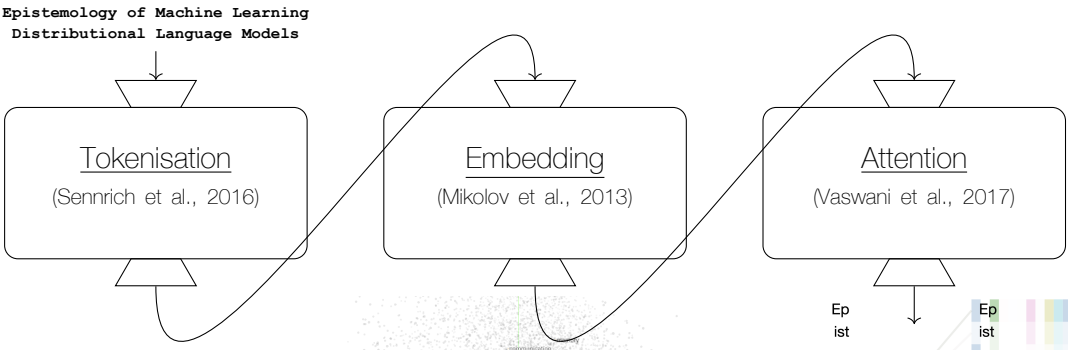

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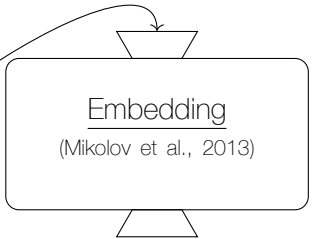

Epistemology of Machine Learning
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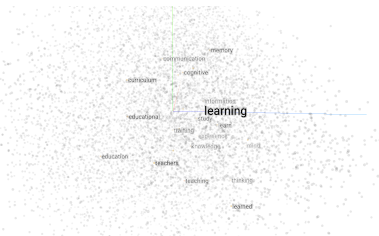


(https://projector.tensorflow.org)

La structure des embeddings

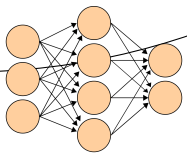
Structure

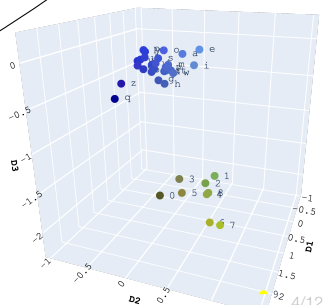
?

{-, /, 0, 1, 2, . . . , 8, 9, =,
a, b, c, . . . , w, x, y, z, é}

Embedding

Données





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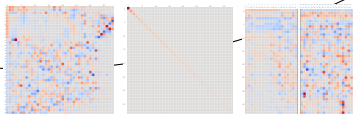
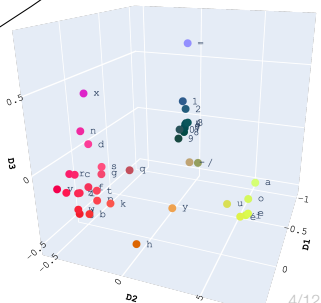
Embedding

Données

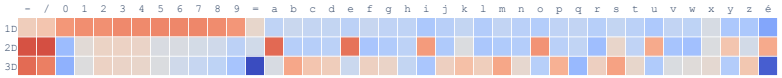


SVD



La structure des embeddings

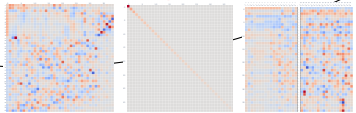
Structure



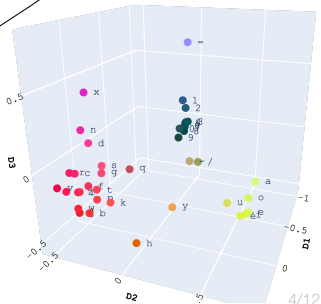
{-, /, 0, 1, 2, . . . , 8, 9, =,
a, b, c, . . . , w, x, y, z, é}

Embedding

Données



SVD



La structure des embeddings

Structure

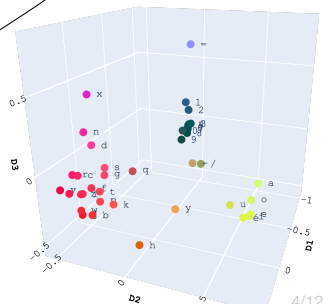
?

Données

$$C^{op} \times D \rightarrow \bar{\mathbb{R}}$$

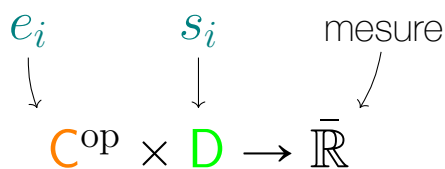
{-, /, 0, 1, 2, . . . , 8, 9, =,
a, b, c, . . . , w, x, y, z, é}

Embedding



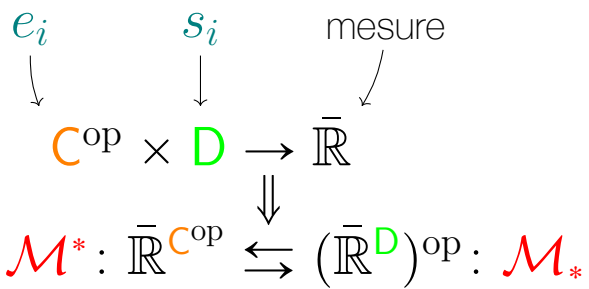
Structure

?

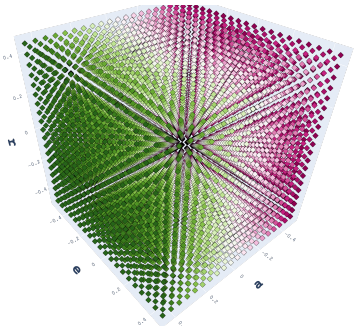


Structure

?


e_i
s_i
mesure
$\mathsf{C}^{\mathrm{op}} \times \mathsf{D} \to \bar{\mathbb{R}}$
$\mathcal{M}^* : \bar{\mathbb{R}}^{\mathsf{C}^{\mathrm{op}}} \leftrightarrows (\bar{\mathbb{R}}^{\mathsf{D}})^{\mathrm{op}} : \mathcal{M}_*$

Structure

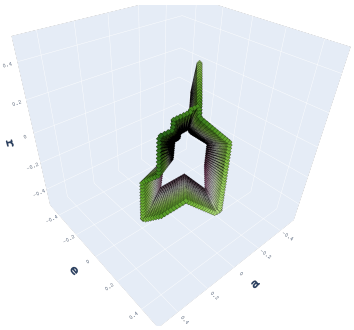


$$\mathsf{C}^{\mathrm{op}} \times \mathsf{D} \longrightarrow \bar{\mathbb{R}}$$

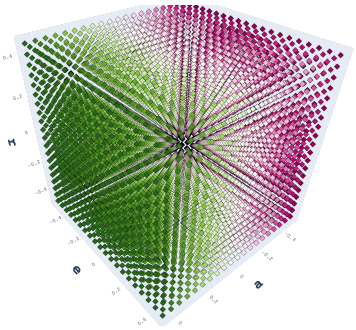
$$\Downarrow$$

$$\mathcal{M}^* \colon \bar{\mathbb{R}}^{\mathsf{C}^{\mathrm{op}}} \leftrightarrows \left(\bar{\mathbb{R}}^{\mathsf{D}}\right)^{\mathrm{op}} \colon \mathcal{M}_*$$

Structure



$\mathcal{M}_*\mathcal{M}^*$

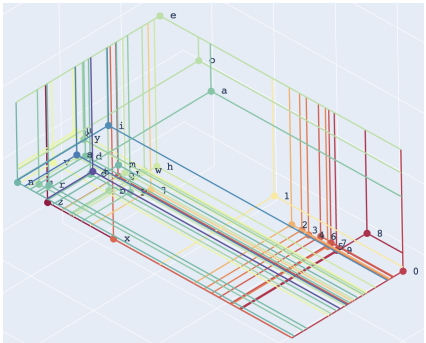


$$\mathsf{C}^{\mathrm{op}} \times \mathsf{D} \longrightarrow \bar{\mathbb{R}}$$

$$\Downarrow$$

$$\mathcal{M}^* : \bar{\mathbb{R}}^{\mathsf{C}^{\mathrm{op}}} \leftrightarrows (\bar{\mathbb{R}}^{\mathsf{D}})^{\mathrm{op}} : \mathcal{M}_*$$

Structure



$$\mathsf{C}^{\mathrm{op}} \times \mathsf{D} \longrightarrow \bar{\mathbb{R}}$$

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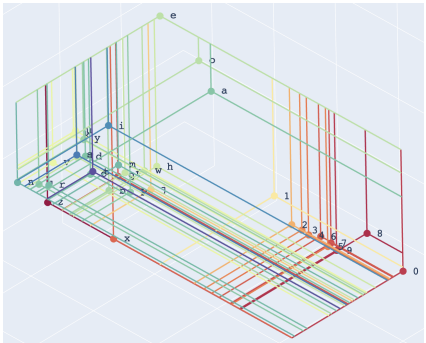
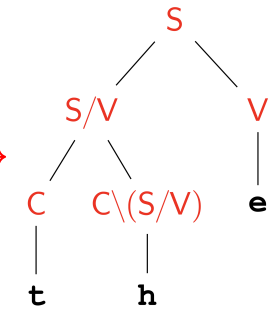


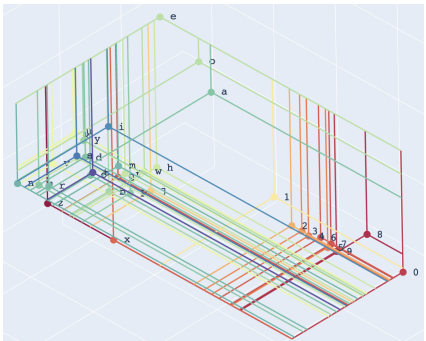


$$\mathsf{C}^{\mathrm{op}} \times \mathsf{D} \longrightarrow \bar{\mathbb{R}}$$

$$\mathcal{M}^* : \bar{\mathbb{R}}^{\mathsf{C}^{\mathrm{op}}} \leftrightarrows \left(\bar{\mathbb{R}}^{\mathsf{D}}\right)^{\mathrm{op}} : \mathcal{M}_*$$

Axe 1: Objectifs

Structure

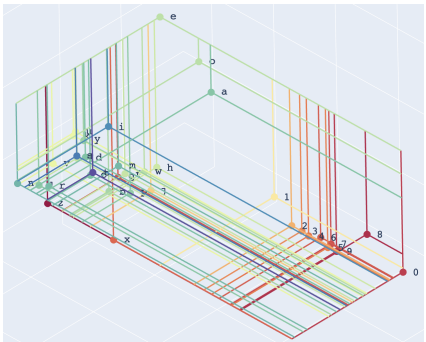


Embedding

Noyau et Types

Axe 1: Objectifs

Structure



Embedding

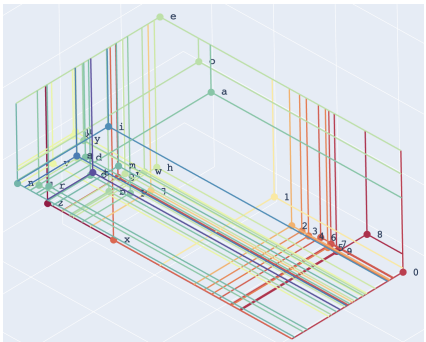
Noyau et Types

Attention

Compositionnalité

Axe 1: Objectifs

Structure



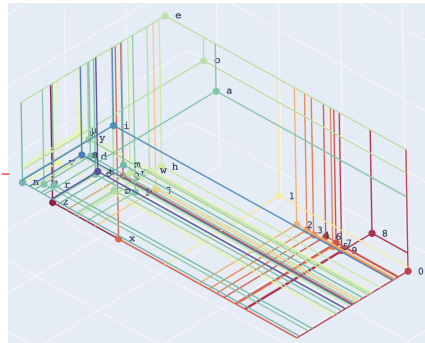
Tokenisation
Mesure et entropie

Embedding
Noyau et Types

Attention
Compositionnalité

Axe 2: Interprétabilité théorique

Structure



Théorie
"Tâche"

?

Axe 2: Interprétabilité théorique

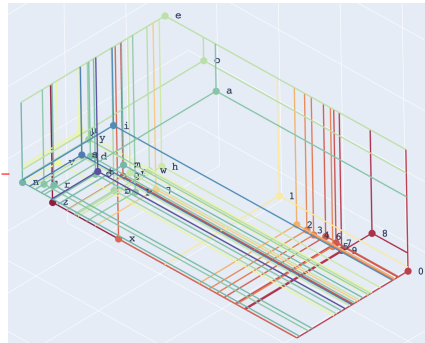
$$C^{\mathrm{op}} \times D \longrightarrow \bar{\mathbb{R}}$$

Hypothèse distributionnelle

Le contenu des unités linguistiques est déterminé par leur ***distribution*** dans un corpus.

Théorie
"Tâche"

Structure



Axe 2: Interprétabilité théorique

$$\mathbf{C}^{\mathrm{op}} \times \mathbf{D} \rightarrow \bar{\mathbb{R}}$$

Hypothèse distributionnelle

Le contenu des unités linguistiques est déterminé par leur *distribution* dans un corpus.

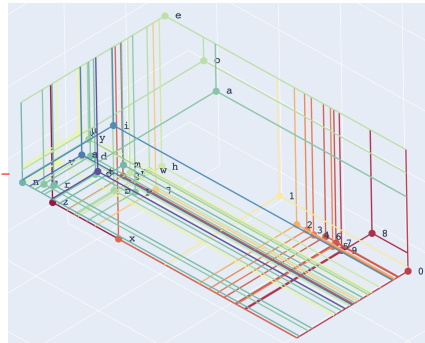
Théorie
"Tâche"

Hypothèse structurale

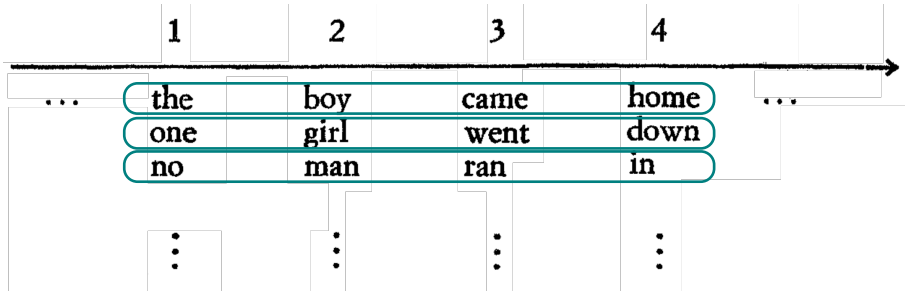
Le contenu linguistique est l'effet d'une **structure** virtuelle dérivée des pratiques linguistiques dans une communauté.

$$\bar{\mathbb{R}}^{\mathbf{C}^{\mathrm{op}}} \leftrightarrows (\bar{\mathbb{R}}^{\mathbf{D}})^{\mathrm{op}}$$

Structure

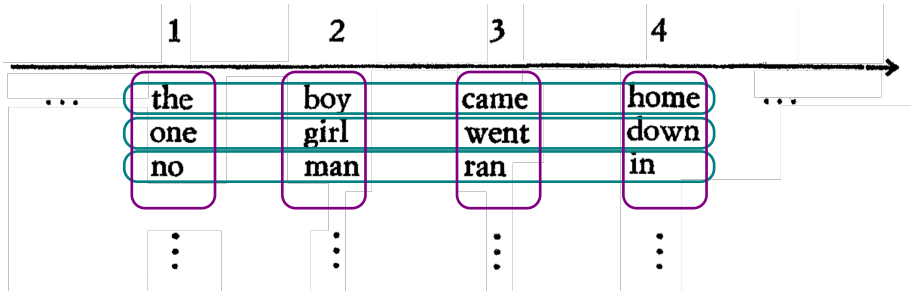


Syntagmes et Paradigmes



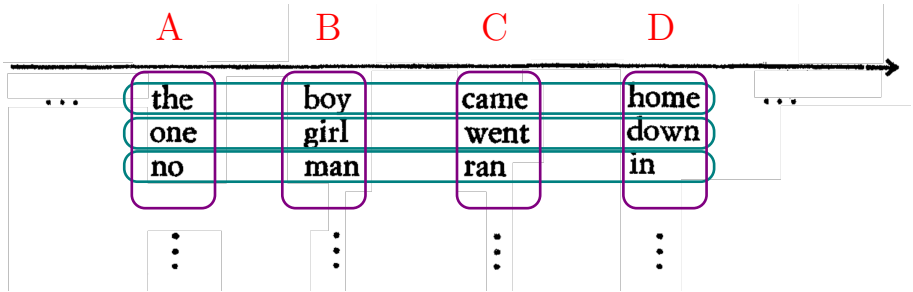
(Hjelmslev, 1971)

Syntagmes et Paradigmes



(Hjelmslev, 1971)

Syntagmes et Paradigmes



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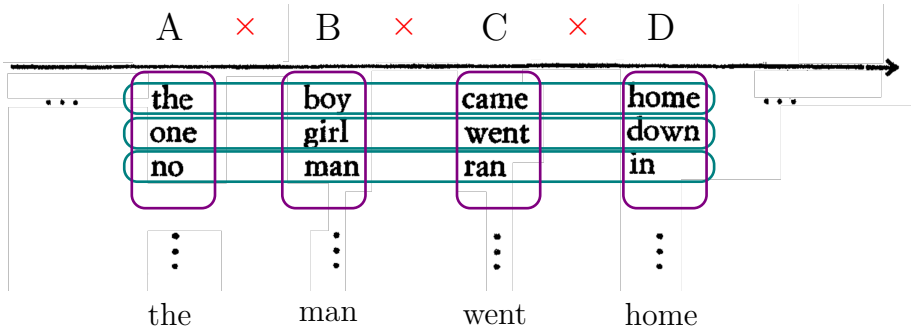
Syntagmes et Paradigmes



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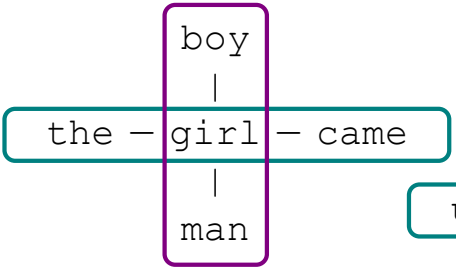
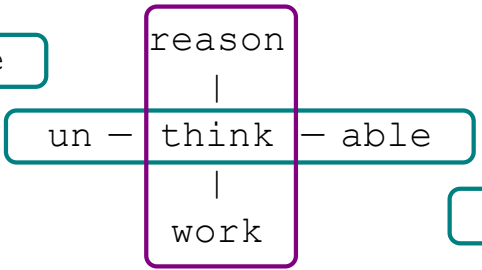
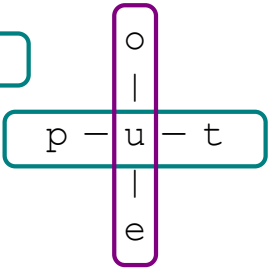
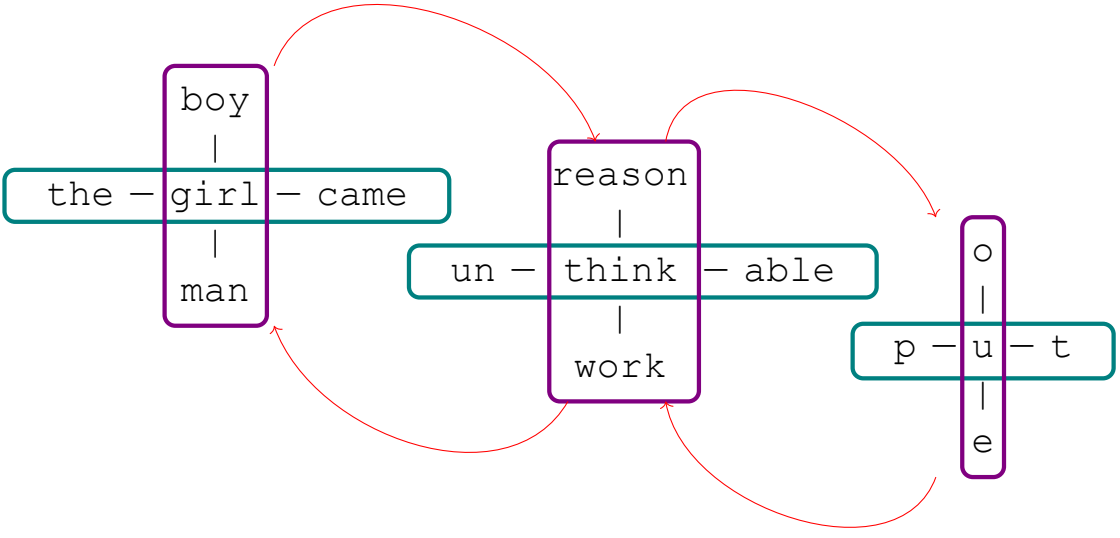
Stratification







Stratification

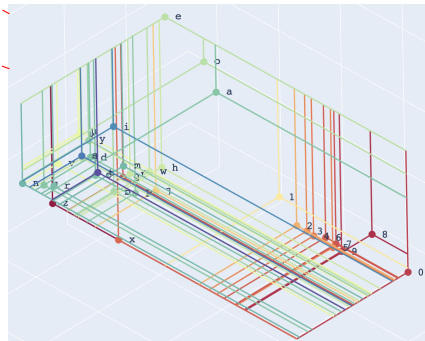


Axe 2: Objectifs

Unités
Classes
Relations

Sémantique
Syntaxe
Morphologie
Phonologie

Structure



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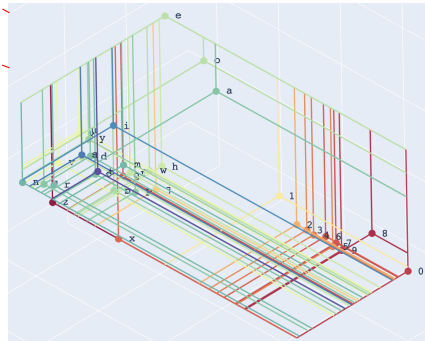

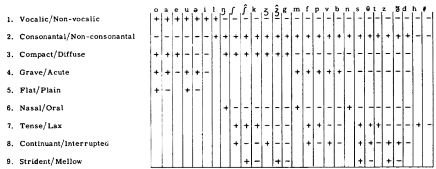

(Jakobson et al., 1952)

Profil

Compétences interdisciplinaires

- **Doctorats** en Philo et en Info (en cours)
- **Publications** en Philo, Info et Maths
  (Phil&Tech, Minds and Machines, Synthese)
  (ACL, ICLR, ICML, AMS)
- **Conférences invitées**
  Montréal, NYC, Cambridge, Montpellier,
  Singapour (6 derniers mois)
  Venice (keynote), Dagstuhl (2 mois prochains)

Participation dans la communauté scientifique

- **(Vice)-Président** de HaPoC
- **Évaluateur** pour Horizon Europe (MSCA)
- **Reviewer** (Nature SR, Phil&Tech, HSSC, ACL)

Gestion de la recherche

- **Directeur** du Dép. de Rech. (MO.CO.ESBA)
- **Directeur executif** du Turing Center (ETH)
- **Marie Skłodowska-Curie** Fellow
- **Projet** "Human Forms"
  (soumis à E. Schmidt Foundation)
- **Cluster** "Foundations of AI"
  (CUNY, Simons Foundation)

Enseignement et encadrement

- **Enseignement** interdisciplinaire international
  (Argentine, France, Tchéquie, Suisse)
- **Encadrement** d'étudiants
  en Philosophie, Informatique, Art (L, M)

Intégration

LIPN, UMR 7030 (Paris)

- Équipe **LoCal** (Logique et Calcul)
- Accent sur les **fondements**
  (théorie des types, théorie de catégories, TAL)
- **Rapprochement** de différentes équipes
  (eg. axe "Sc. des données")
- Forte **interdisciplinarité**
  (santé, linguistique, physique, philosophie)

LIRMM, UMR 5506 (Montpellier)

- Équipe **TEXTE** (Exploration et exploitation de données textuelles)
- Accent sur les **applications**
  (grammaires catégorielles, TAL, th. des types)
- Activités **transversales**
  (eg. axe "IA et Sc. des données")
- Forte **interdisciplinarité**
  (projet Muse: "Nourrir, Soigner, Protéger")

Dans les deux cas

- **Collaboration** et **contact** avec des membres et la direction
- Intégration des aspects **épistémologiques** et **sociétaux** dans la recherche
- Présentation de mon travail aux équipes

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CNRS - Concours chercheurs 2025
CR Section 53 - Concours n° 53/03

Épistémologie des modèles distributionnels de langage par apprentissage machine

Explicabilité formelle et interprétabilité théorique

Juan Luis Gastaldi

`http://www.jlgastaldi.com/assets/gastaldi_cnrs_cr.pdf`

ETH zürich

12 Mai 2025