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Toward a Critical Formalism

From the Philosophy to the Theory of Distributional Language Models

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Outline

Introduction

NLMs as Formal Objects

Conclusion

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The Epistemology of AI

Where Art Thou, Critique?

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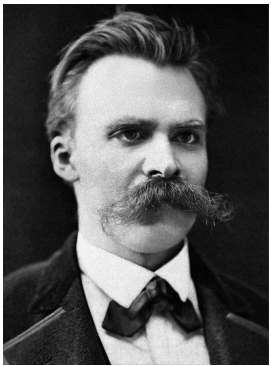
- Good “externalist” critique

- Poor “internalist” critique
  - The main “critical” reference remains the “Stochastic Parrots” approach (Bender & Koller, 2020; Bender et al., 2021)

  - Kirschenbaum (2023):
    Bender et al.’s (2021) paper “offers a disarmingly linear account of how language, communication, intention, and meaning work, one that would seem to sidestep decades of scholarship around these same issues in literary theory [...] the passage would be red meat for a graduate critical-theory seminar.”

  - Underwood (2023):
    “The beautiful irony of this situation [...] is that a generation of humanists trained on Foucault have now rallied around “On the Dangers of Stochastic Parrots” to oppose a theory of language that their own disciplines invented, just at the moment when computer scientists are reluctantly beginning to accept it.”

The Birth of Contemporary Critique



"In some remote corner of the universe, flickering in the light of the countless solar systems into which it had been poured, there was once a planet on which clever animals invented cognition. It was the most arrogant and most mendacious minute in the 'history of the world'…"

"On Truth and Lying in a Non-Moral Sense"
(Nietzsche, 1873)

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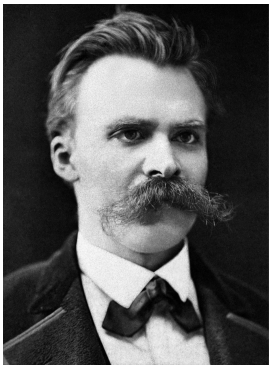

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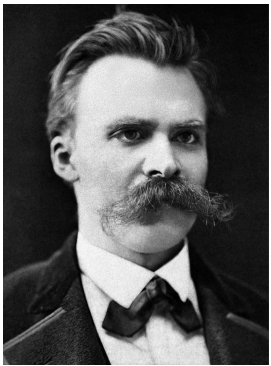

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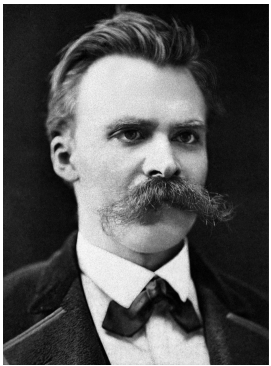

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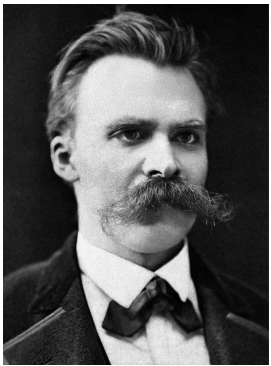

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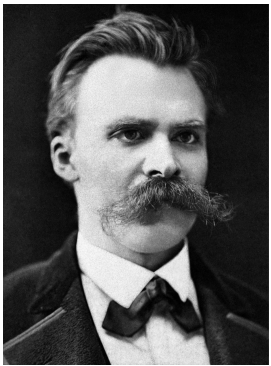

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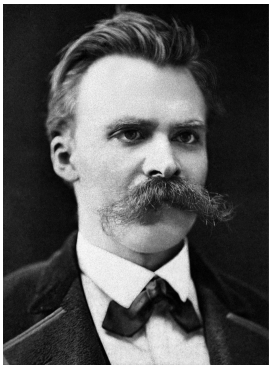

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- “…each word immediately becomes a concept […] because at the same time it must fit […] nothing other than nonequivalent cases.”

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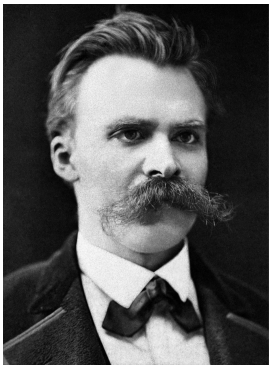

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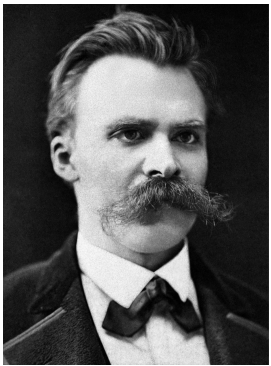

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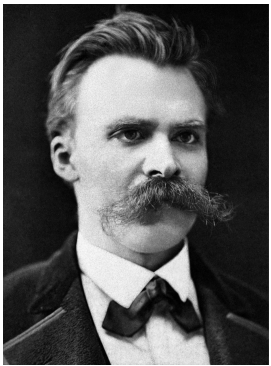

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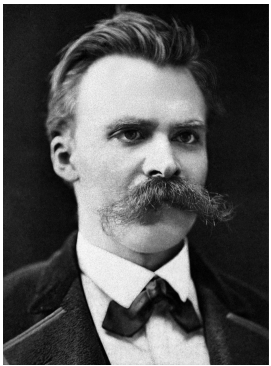

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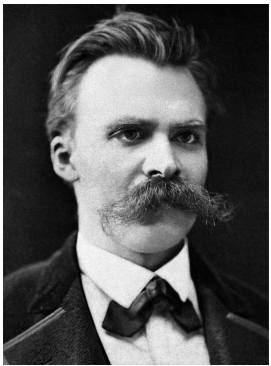

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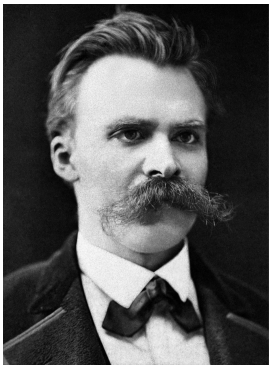

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- “...precisely *because of this unconsciousness*, precisely because of this forgetting, they arrive at the feeling of truth.”

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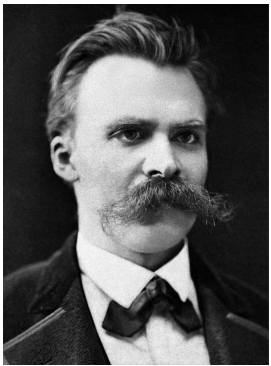

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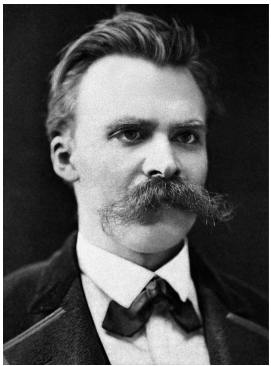

- “between [...] subject and object [...] there is [...] at most an *aesthetic* way of relating”
- “Where the man of intuition [...] wields his weapons more mightily and victoriously than his contrary, a culture can take shape [...] and the rule of art over life can become established”

Criticism and Formalism

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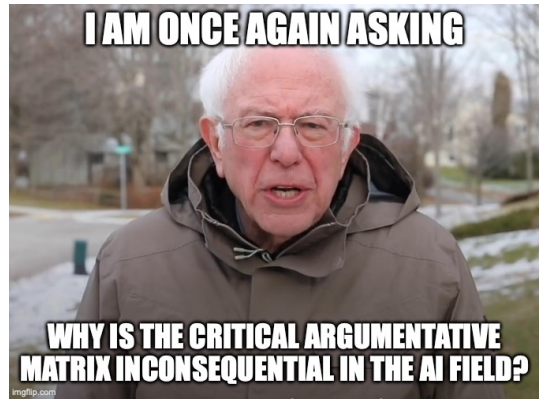

The Critical Argumentative Matrix

Knowledge depends on language

The relation between language and the world is essentially arbitrary

Any regularity in language/knowledge is not natural but cultural/social/political

We should resist existing regularities and create new ones

The Critical Argumentative Matrix

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(Epistemological)

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The relation between language and the world is essentially arbitrary

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Any regularity in language/knowledge is not natural but cultural/social/political
(Political)

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Critique and Formalism

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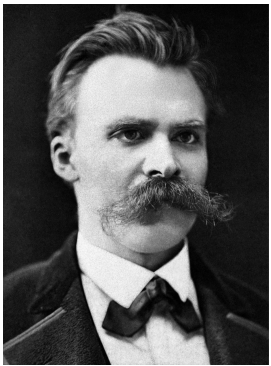
Criticism vs Formalism



- “their eyes merely glide across the surface of things and see ‘forms’; nowhere does their perception lead into truth; instead it is content to receive stimuli and, as it were, to play with its fingers on the back of things.”

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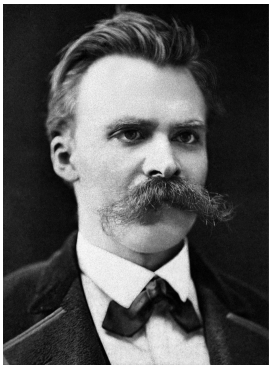

- "their eyes merely glide across the surface of things and see 'forms'; nowhere does their perception lead into truth; instead it is content to receive stimuli and, as it were, to play with its fingers on the back of things."
- "...the great edifice of concepts exhibits the rigid regularity of a *Roman columbarium*, while logic breathes out that air of severity and coolness which is peculiar to mathematics."
- "...if we are forced to comprehend all things under these forms alone, then it is no longer wonderful that what we comprehend in all these things is actually nothing other than these very forms; for all of them must exhibit the laws of number, and number is precisely that which is most astonishing about things."
- "...the only things we really know about them [laws of nature] are things which we bring to bear on them: time and space, in other words, relations of succession and number."

For a Critical Formalism

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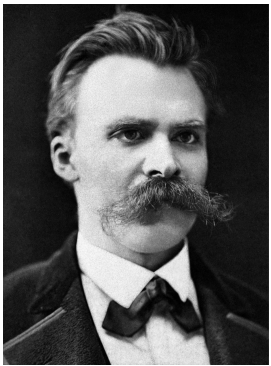
- We need a new strategy: Elaborate a critical formalism

For a Critical Formalism



"...all peoples have just such a mathematically divided firmament of concepts above them [...] Here, one can certainly admire humanity as a mighty architectural genius who succeeds in erecting the infinitely complicated cathedral of concepts on moving foundations, or even, one might say, on flowing water; admittedly, in order to rest on such foundations, it has to be like a thing constructed from cobwebs, so delicate that it can be carried off on the waves and yet so firm as not to be blown apart by the wind."

(Nietzsche, 1873)

For a Critical Formalism

- In the case of AI, a critical formalism can provide:
  - New epistemological tools countering dogmatic perspectives stemming from within the field
  - New theoretical tools contributing to the non-dogmatic positive production of knowledge

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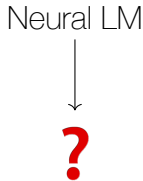
Neural LMs as Computable Functions



Neural LMs as Computable Functions

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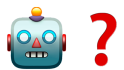

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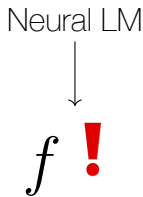

Neural LMs as Computable Functions

Neural LM

Function

$$f\colon \mathbb{R}^n \xrightarrow{f_1} \mathbb{R}^{n_1} \xrightarrow{f_2} \dots \xrightarrow{f_K} \mathbb{R}^{n_K} \xrightarrow{g} \mathbb{R}^m$$

Neural LMs as Computable Functions

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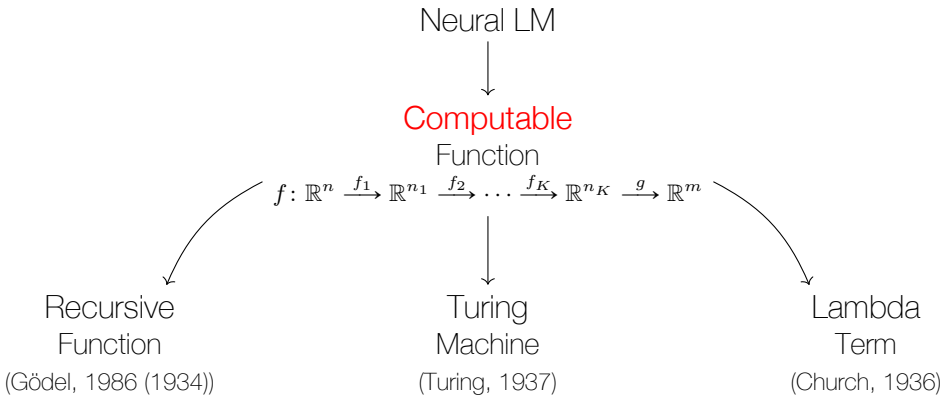
↓

Turing

Machine

(Turing, 1937)

Neural LMs as Computable Functions



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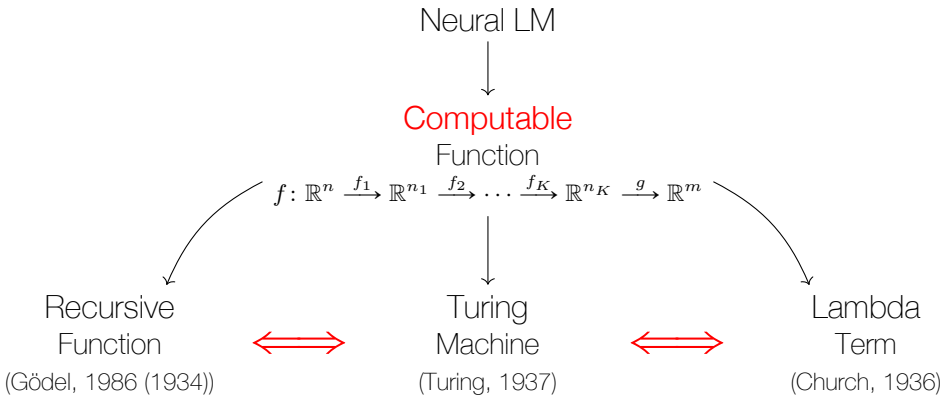

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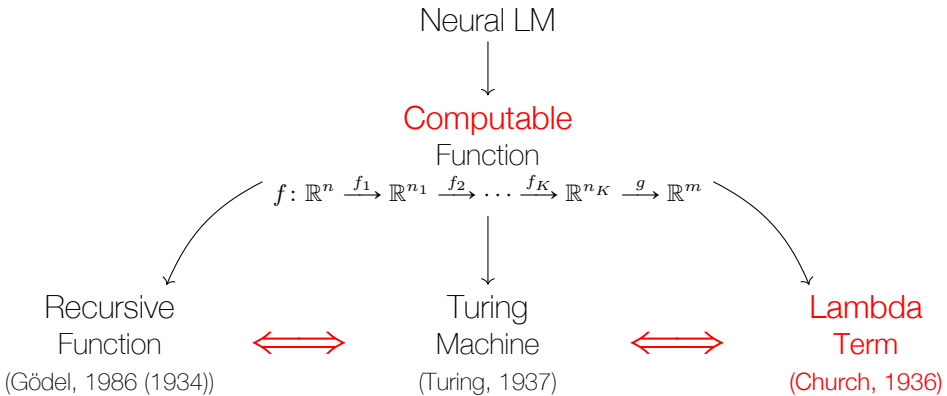

Neural LMs as Computable Functions

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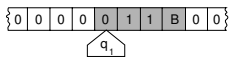
Recursive Function	⟺	Turing Machine	⟺	Lambda Term
(Gödel, 1986 (1934))		(Turing, 1937)		(Church, 1936)



$\lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)$

credit: Nynexman4464

β-reduction in λ-calculus

$$yxz$$

β-reduction in λ-calculus

$$\lambda x.yxz$$

β-reduction in λ-calculus

$$(\lambda x.yxz)t$$

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$$(\lambda x.yxz)t$$

$$\downarrow\!\!\!\!\!\!\sim$$

$$ytz$$

Empirical Evaluation

$$P := \lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)$$

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1: $\lambda f.\lambda x.fx$

2: $\lambda f.\lambda x.f(fx)$

3: $\lambda f.\lambda x.f(f(fx))$

4: $\lambda f.\lambda x.f(f(f(fx)))$

5: $\lambda f.\lambda x.f(f(f(f(fx))))$

$\ldots$

n: $\lambda f.\lambda x.\underbrace{f(\ldots(f}_{n \text{ times}}x)\ldots)$

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Empirical Evaluation

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$P' := \lambda r.\lambda s.\lambda f.\lambda x.f(f(f(f(fx))))$

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Interpretability

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n: $\lambda f.\lambda x.\underbrace{f(\ldots(f}_{n \text{ times}}x)\ldots)$

$$\lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)(\lambda f.\lambda x.f(fx))(\lambda f.\lambda x.f(f(fx)))$$
$$\lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)(\lambda g.\lambda y.g(gy))(\lambda h.\lambda z.h(h(hz)))$$
$$\lambda n.\lambda f.\lambda x.(\lambda g.\lambda y.g(gy))f(nfx)(\lambda h.\lambda z.h(h(hz)))$$
$$\lambda n.\lambda f.\lambda x.(\lambda g.\lambda y.g(gy))f(nfx)(\lambda h.\lambda z.h(h(hz)))$$
$$\lambda f.\lambda x.(\lambda g.\lambda y.g(gy))f((\lambda h.\lambda z.h(h(hz)))fx)$$
$$\lambda f.\lambda x.(\lambda y.f(fy))((\lambda h.\lambda z.h(h(hz)))fx)$$
$$\lambda f.\lambda x.(\lambda y.f(fy))((\lambda z.f(f(fz)))x)$$
$$\lambda f.\lambda x.(\lambda y.f(fy))(f(f(fx)))$$
$$\lambda f.\lambda x.f(f(f(f(fx))))$$

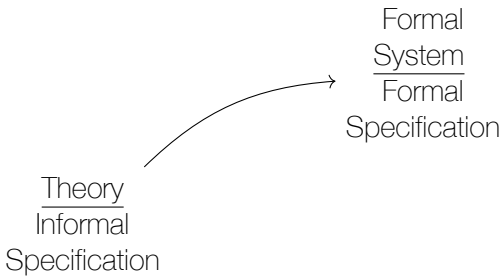
$P := \lambda m.\lambda n.\lambda f.\lambda x.mf(nfx)$

P'' :=λRófÄÒêÑ5È|Àxñ=∞ù ÿmWf286ëy’SÒú>v&ìÂ ¬2 óÉ7öç∞{ã>2flB°µG#À9ÇU ∞btYBô¥ Ù ë‰3;5 å[l–èuô¨Ü ˚ 7–Ù.λ:ˆ4mÓØ¥´è—+ÌsÖ,$+gï„B™÷o–#ïŸê Ûv –gÓÿ/ëiijO‡Œfi • J1«€ø¸Ï hãêt‡æY$ˆ6 FïW»RÙKg¢¨.λ‡d¯… D2÷¸ò ˚ xêÈy. Ó”¢b Bé£NÈ1Ê‡/Û9Ñµ–/JYÇõË9ÿÀÈ.λÁÍ À^öÇ,»fq∞±îˇB5Ì>O˜g™“6Ωe“æëC/ã… Ö · fÓ Å]ÑåyÊN°Ê ›¨.λÆà€fUòfEÙ·Í m#„¸4\r√¬÷Îpò»y*vtÄJÃF1ûÁóz«ñM”DjŒ BËèÍT _ Êa‰ÁÇΩ @\Øˆ˜]Î›h‡.:ˆ4mÓØ¥´è—+ÌsÖ,$+gï„B™÷o–#ïŸê Ûv–gÓÿ /ëiijO‡Œfi • J1«€ø¸Ï hãêt‡æY$ˆ6 FïW»RÙKg¢¨ÁÍ À^öÇ,»fq∞±îˇB5Ì>O˜g™“6 Ωe“æëC/ã… Ö · fÓ Å]ÑåyÊN°Ê ›¨(‡d¯… D2÷¸ò ˚ xêÈy. Ó”¢bBé£NÈ1Ê‡/Û9Ñµ–/ JYÇõË9ÿÀÈÁÍ À^öÇ,»fq∞±îˇB5Ì>O˜g™“6Ωe“æëC/ã… Ö · fÓ Å]ÑåyÊN°Ê ›¨Æ à€fUòfEÙ·Í m#„¸4\r√¬÷Îpò»y*vtÄJÃF1ûÁóz«ñM”DjŒBËèÍT _ Êa‰ÁÇΩ @\ Øˆ˜]Î›h‡)(ËÎÛeí4WµÍ }w„$Ω“K5èÃ¶%3[m ’˜BÃfifÒ; óJçCËîõŸØcB,ñ$Åå}ÓÅØ3¡ ˇ?ö¯oŒ@ fl8ˇR CÆoˇ* &<Ÿ ¬o12À‰ àÓÜ#ï ″,ú¨ «ô¸„∞Îâä“øÃd|ˆÑ’Ê yØ;ˆW ›″wò[}\»ÖÈúw’6<ùˇ=ãÕ ¯Ì‘Dz?2±|é‘ 3Â/rxµ∞µ$ÀëÂ*lf˜îû’+ÍVìy[a]Gæßägô/,uÑ)

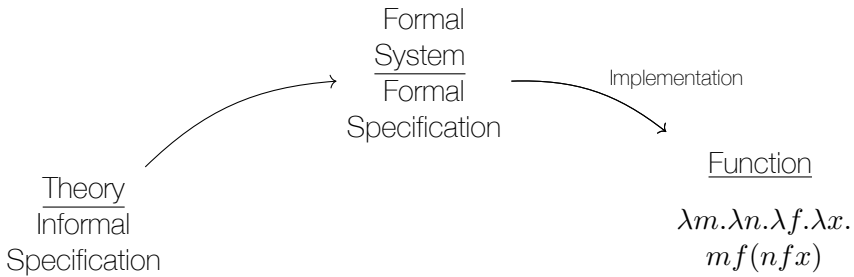
Making it Explicit

Theory
Informal
Specification

Making it Explicit



Making it Explicit



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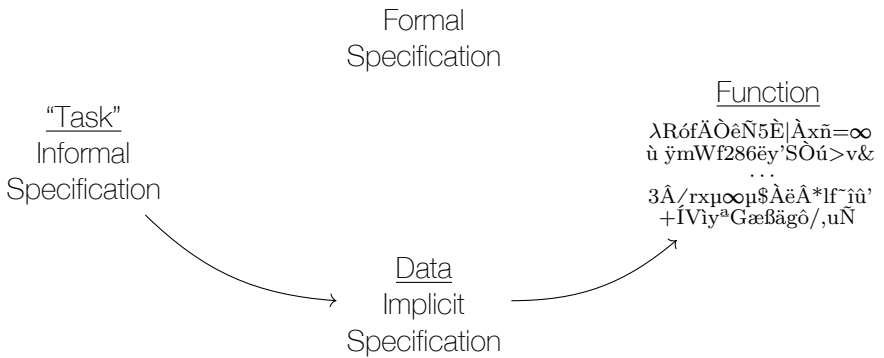
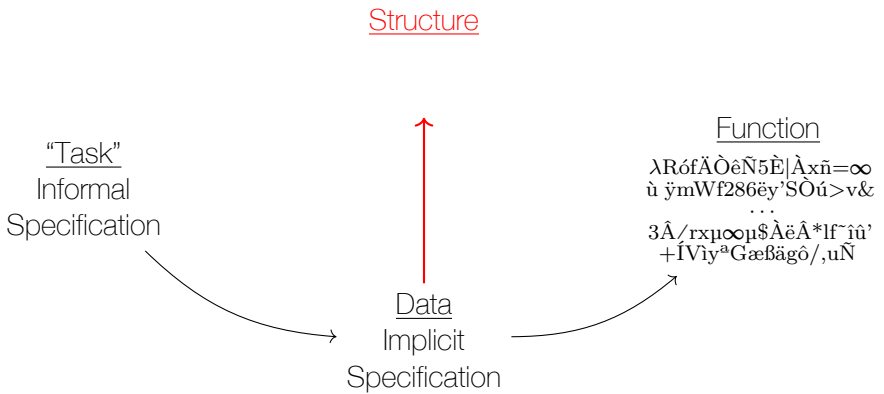
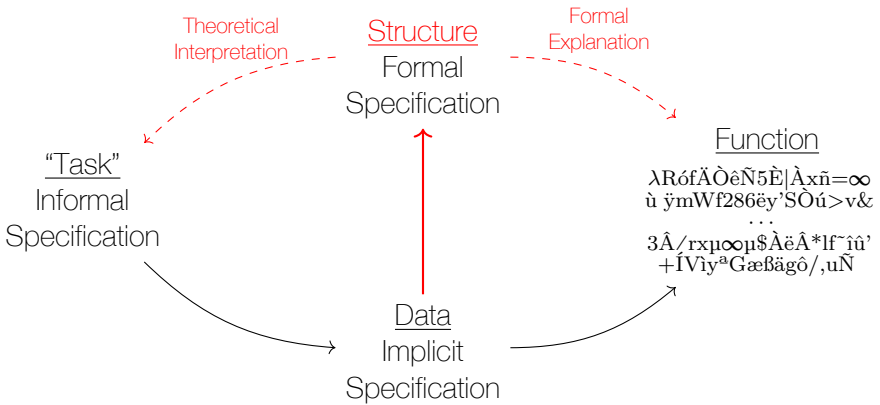


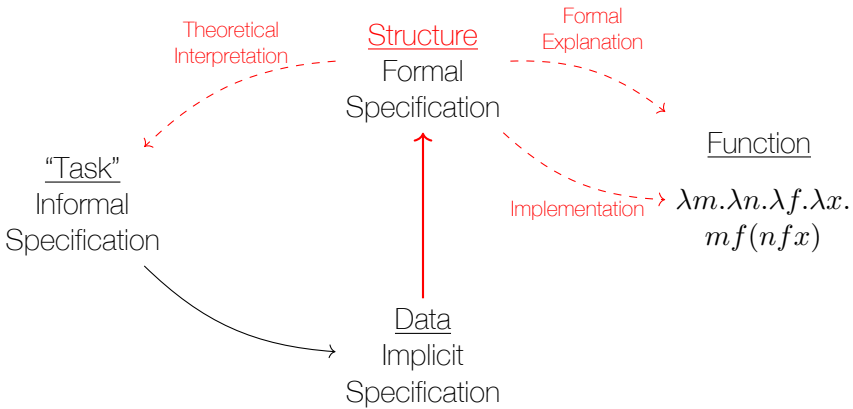
Making it Explicit



Making it Explicit



Making it Explicit



Outline

Introduction

NLMs as Formal Objects

Conclusion

Conclusion: For a Critical Formalism

- It is urgent to address the epistemological dimension of the critical project in its own terms
- This requires to develop a critical approach within formal sciences where formalization is not assumed to lead to naturalization
  - The new role of data within formal sciences is crucial in this sense
- A critical formalism will be incomplete if it remains disconnected from the political, and even the artistic dimension of the critical program
  - We need a new alliance between the formal sciences, the human sciences, and the arts.

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Toward a Critical Formalism

From the Philosophy to the Theory of Distributional Language Models

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