Group 26:
(Foundation for Near-Term Quantum Natural Language Processing)

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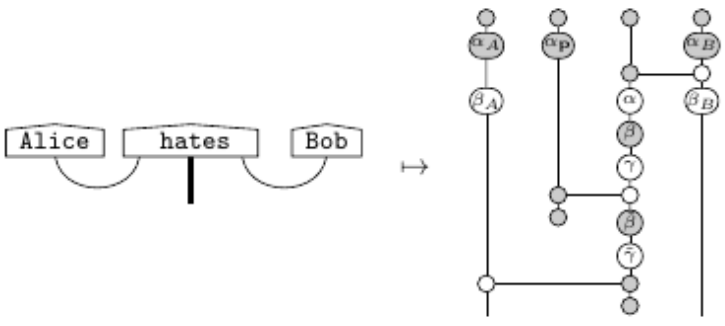
CSE-712
Brac University

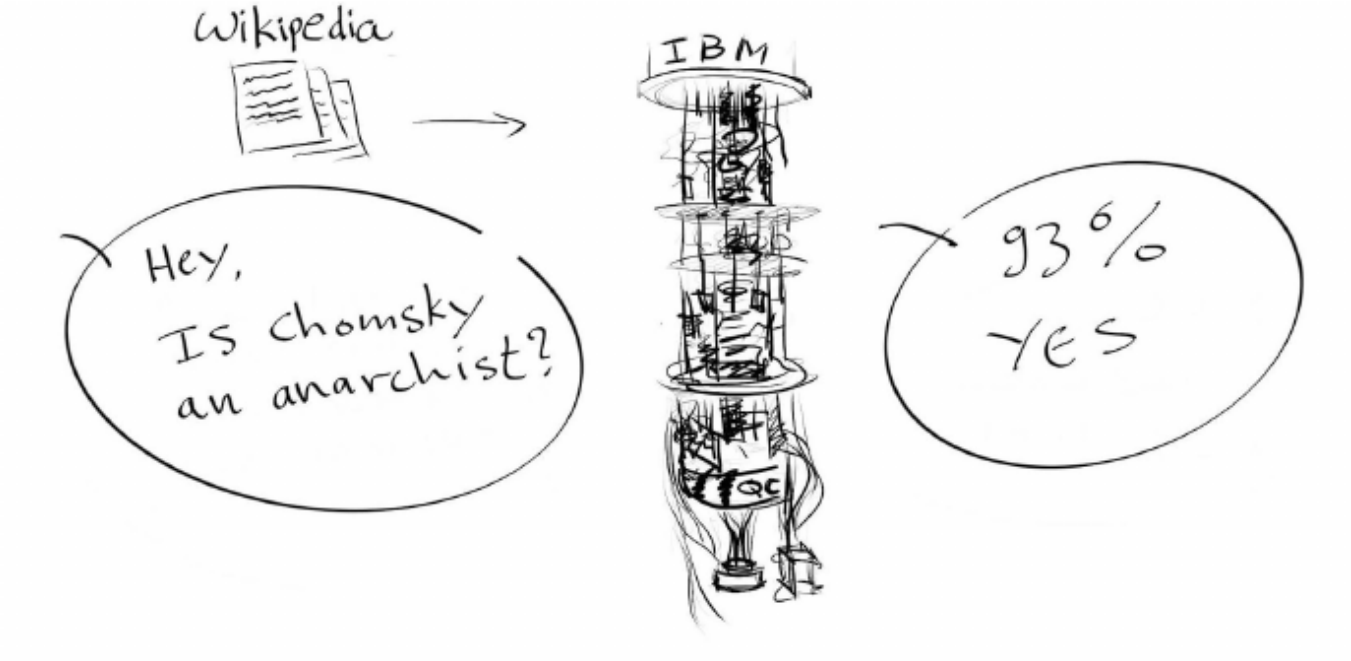


Where to look:

Where to look:

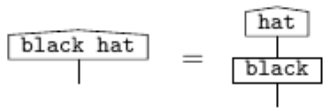
- Canonically combines structure and meaning.
- Apparently exponentially expensive classical encoding of grammar to free lunch!
- Diagrammatic formalism of CQM.
- DisCoCat
- ZX-calculas
- Wittenstein's meaning-is-context.

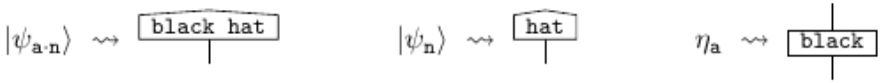
Quantum model for natural language


Wikipedia
IBM
Hey,
Is Chomsky
an anarchist?
93%
YES

Applying "adjective" to a "noun"

$$|\psi_{\mathrm{a}\cdot\mathrm{n}}\rangle \;=\; \eta_{\mathrm{a}}\Big(|\psi_{\mathrm{n}}\rangle\Big)$$

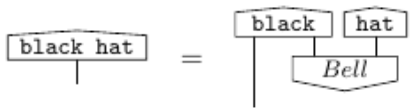


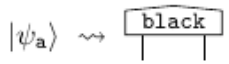


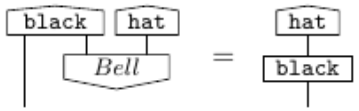
Applying "adjective" to a "noun"

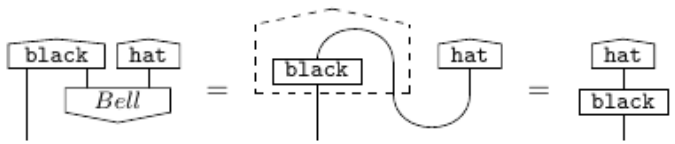
$$\eta_{00}|0\rangle\langle 0| + \eta_{01}|0\rangle\langle 1| + \eta_{10}|1\rangle\langle 0| + \eta_{11}|1\rangle\langle 1| \quad \mapsto \quad \eta_{00}|00\rangle + \eta_{01}|01\rangle + \eta_{10}|10\rangle + \eta_{11}|11\rangle$$

$$|\psi_{\mathtt{a}\cdot\mathtt{n}}\rangle \;=\; \Big(\mathbb{I}\otimes\langle Bell|\Big)\circ\Big(|\psi_{\mathtt{a}}\rangle\otimes|\psi_{\mathtt{n}}\rangle\Big)$$



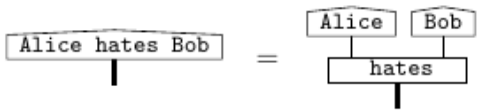


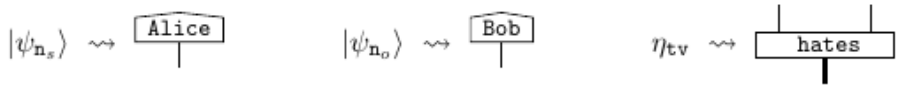


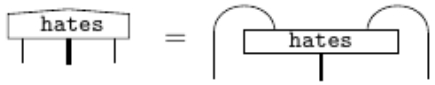


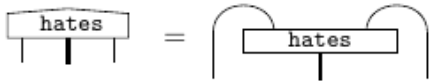
Feeding a "subject" and an "object" into a "verb":

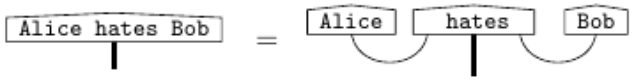
$$|\psi_{\mathtt{n}_s \mathtt{tv} \cdot \mathtt{n}_o}\rangle = \eta_{\mathtt{tv}}\Big(|\psi_{\mathtt{n}_s}\rangle \otimes |\psi_{\mathtt{n}_o}\rangle\Big)$$











$$|\psi_{\mathtt{n}_s \mathtt{tv} \cdot \mathtt{n}_o}\rangle = \Big(\langle Bell| \otimes \mathbb{I} \otimes \langle Bell|\Big) \circ \Big(|\psi_{\mathtt{n}_s}\rangle \otimes |\psi_{\mathtt{tv}}\rangle \otimes |\psi_{\mathtt{n}_o}\rangle\Big)$$

FUNCTIONAL WORDS SUCH AS RELATIVE PRONOUNS:

$$= \sum_i |i \dots i\rangle\langle i \dots i|$$

$$= \sum_i |ii\rangle\langle i|$$

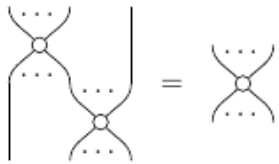
$$= \sum_i |i\rangle\langle ii|$$

$$= \sum_i \langle i|$$

$$= \sum_i |i\rangle\langle i|$$

$$= \sum_i |ii\rangle$$

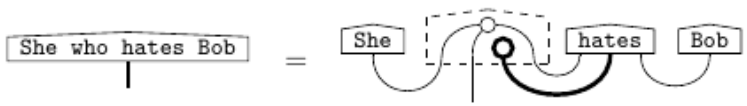
$$= \sum_i \langle ii|$$

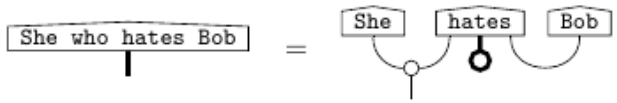


$$|\psi_{\texttt{who}}\rangle = \Big(|00\rangle\Big(\sum_i |i\rangle\Big)|0\rangle\Big) + \Big(|11\rangle\Big(\sum_j |j\rangle\Big)|1\rangle\Big)$$

$$|GHZ\rangle \;=\; |000\rangle + |111\rangle$$

FUNCTIONAL WORDS SUCH AS RELATIVE PRONOUNS:

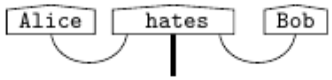


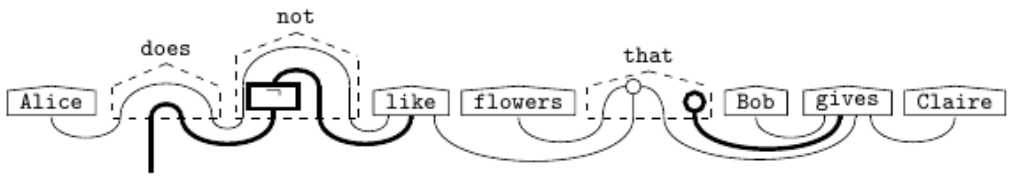


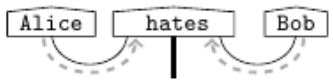
$$|\psi_{\mathbf{n}_h \mathbf{rp} \mathbf{tv} \mathbf{n}_o}\rangle = \Big((|0\rangle\langle 00| + |1\rangle\langle 11|) \otimes \Big(\sum_{j=1}^{j=k} \langle j| \Big) \otimes \langle Bell| \Big) \circ \Big(|\psi_{\mathbf{n}_h}\rangle \otimes |\psi_{\mathbf{tv}}\rangle \otimes |\psi_{\mathbf{n}_o}\rangle \Big)$$

THE GENERAL CASE:

$$f_{\mathcal{G}}\Big(|\psi_{\mathtt{w}_1}\rangle \otimes \ldots \otimes |\psi_{\mathtt{w}_N}\rangle\Big)$$







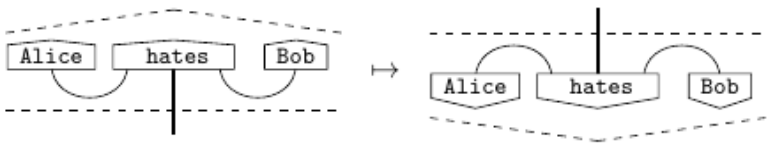
Grammar is what mediates the flows of meanings between words.

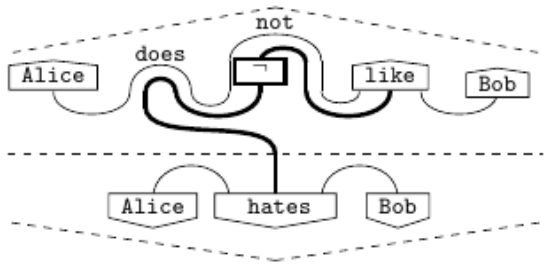
COMPARING MEANINGS:

Alice hates Bob and Alice does not like Bob

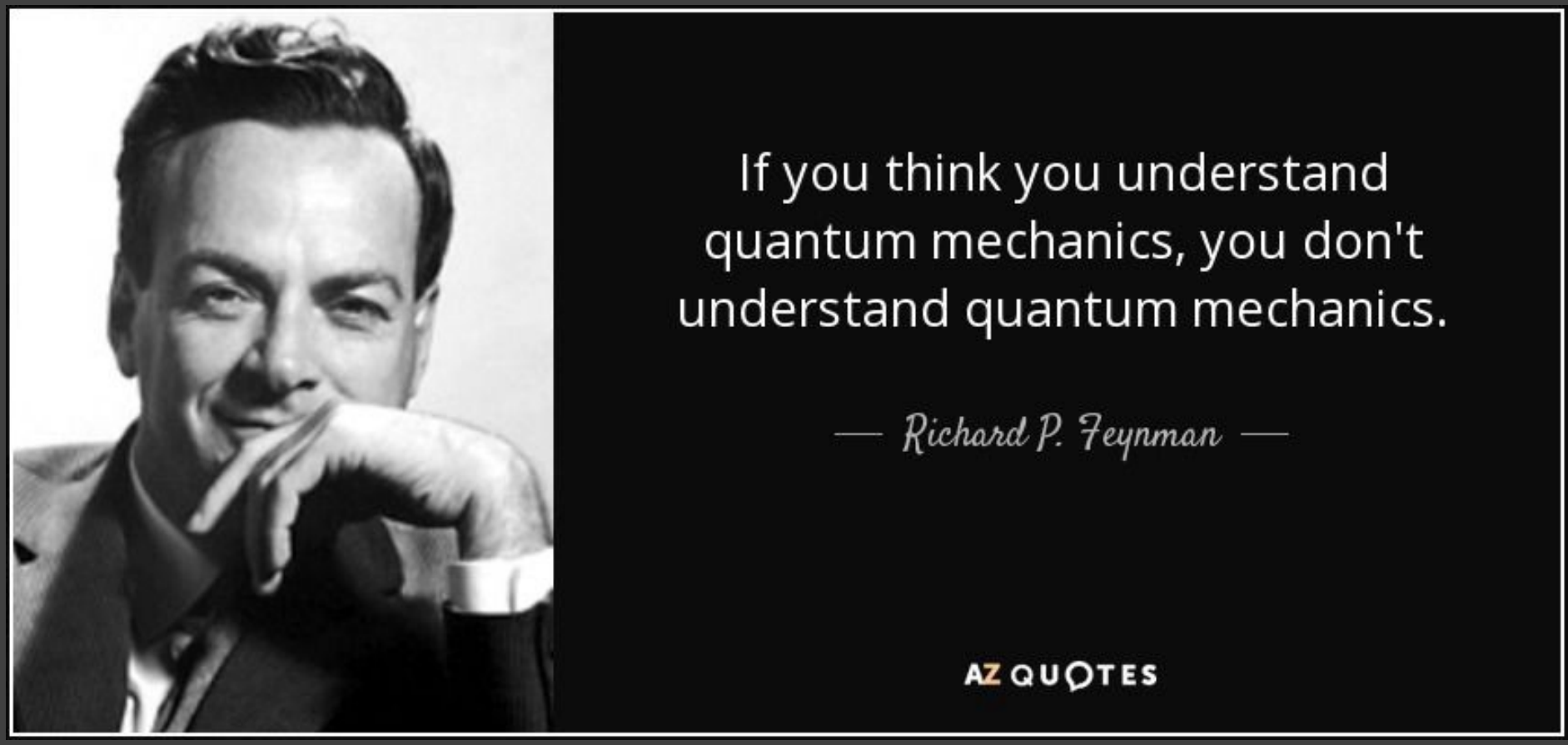
$$|\psi_{w_1 \cdots w_N}\rangle \mapsto \langle \psi_{w_1 \cdots w_N}|$$

$$\langle \psi_{w_1 \cdots w_N} | \psi_{w'_1 \cdots w'_N} \rangle$$





Free lunch!!


If you think you understand quantum mechanics, you don't understand quantum mechanics.
— Richard P. Feynman —
AZ QUOTES