# Neural networks

Natural language processing - language modeling

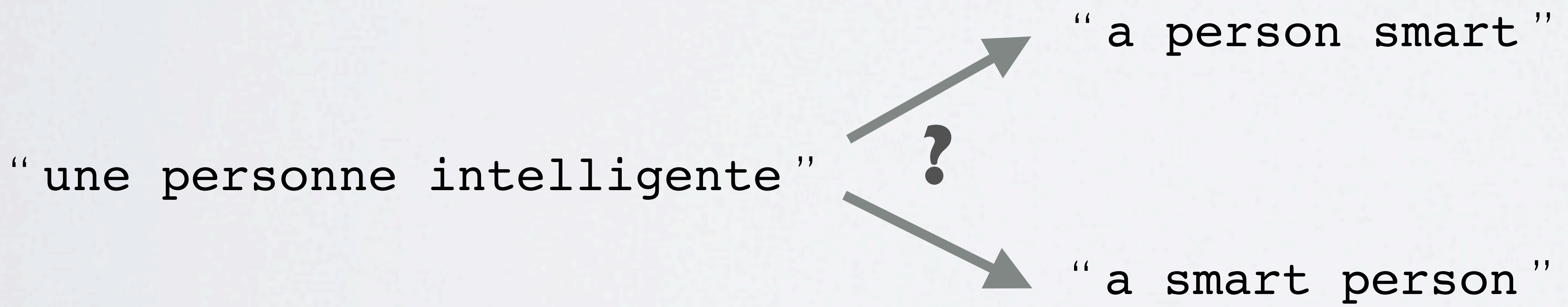
# LANGUAGE MODELING

**Topics:** language modeling

- A language model is a probabilistic model that assigns probabilities to any sequence of words

$$p(w_1, \; \dots \; , w_T)$$

  - language modeling is the task of learning a language model that assigns high probabilities to well formed sentences
  - plays a crucial role in speech recognition and machine translation systems



# LANGUAGE MODELING

**Topics:** language modeling

- An assumption frequently made is the $n^{\text{th}}$ order Markov assumption

$$p(w_1, \ldots, w_T) = \prod_{t=1}^{T} p(w_t \mid w_{t-(n-1)}, \ldots, w_{t-1})$$

  - the $t^{\text{th}}$ word was generated based only on the $n-1$ previous words
  - we will refer to $w_{t-(n-1)}, \ldots, w_{t-1}$ as the context

# LANGUAGE MODELING

**Topics:** $n$-gram model

- An $n$-gram is a sequence of $n$ words
  - unigrams ($n$=1): "**is**", "**a**", "**sequence**", etc.
  - bigrams ($n$=2): ["**is**", "**a**"], ["**a**", "**sequence**"], etc.
  - trigrams ($n$=3): ["**is**", "**a**", "**sequence**"], [ "**a**", "**sequence**", "**of**"], etc.
- $n$-gram models estimate the conditional from $n$-grams counts

$$p(w_t \mid w_{t-(n-1)}, \dots, w_{t-1}) = \frac{\text{count}(w_{t-(n-1)}, \dots, w_{t-1}, w_t)}{\text{count}(w_{t-(n-1)}, \dots, w_{t-1}, \cdot)}$$

  - the counts are obtained from a training corpus (a data set of word text)

# LANGUAGE MODELING

**Topics:** $n$-gram model

- Issue: data sparsity
  - we want $n$ to be large, for the model to be realistic
  - however, for large values of $n$, it is likely that a given $n$-gram will not have been observed in the training corpora
  - smoothing the counts can help
    - combine $\mathrm{count}(w_1 , w_2 , w_3 , w_4)$, $\mathrm{count}(w_2 , w_3 , w_4)$, $\mathrm{count}(w_3 , w_4)$, and $\mathrm{count}(w_4)$ to estimate $p(w_4 | w_1, w_2, w_3)$
  - this only partly solves the problem