Spatial Gesture Semantics

3. Extemplification and Informational Evaluation

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Recap

Yesterday's lecture

- Spatial gesture semantics
- Drawing, molding, and acting gestures
  - Rotation
  - Scaling
  - Handshape quotation

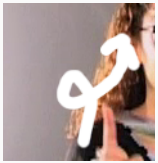
- Conservative, truth-functional extension of standard semantic models
- Two levels of meaning: [ling] and [vis]
- [vis] is lexicalized

Today's lecture

Besides the truth-functional, visuo-spatial semantics of gestures, there is another way of looking at gestures.

Seeing Gestures

Staircases



"Ich g[laube das sollen TREP]pen sein"
I think that should be staircases

(capitalization indicates main stress, square brackets indicate the temporal alignment of speech and gesture)

- visuo-spatial approach:

(vector sequence, see lect. 2)

- labelling approach: $\mathit{spiral}(\gamma) \vee \mathit{curled}(\gamma) \vee \mathit{twined}(\gamma) \vee \mathit{tight}(\gamma) \vee \ldots$

Twofoldedness

"as we see them, we see something in them."[1]

[1] J. Streeck (2008). "Depicting by Gesture". In: Gesture 8, 285–301, 286, original emphasis

Twofoldedness

- *Seeing them* corresponds to a visuo-spatial approach
- *seeing something in them* to a labeling approach

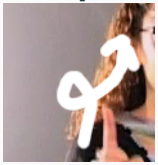
- We already know how to analyse gestures in terms of visuo-spatial semantics (the last two lectures)
- Here we are concerned with labeling approaches: how to derive predicates for describing the semantic contribution of gestures – what we call **informational evaluation**.

Plan of lecture

- Informational evaluation is a heuristic act, and therefore needs a place in a semantic theory of iconic gestures.
- We will draw on insights from fields as diverse as philosophy of language, computational semantics, psychophysics, dynamic semantics, and gesture studies.
- It will turn out that informational evaluation is a semantic act that cannot be described within standard possible worlds semantics.
- Therefore, we develop a semantic heuristic for the working semanticist

The Challenge

Openness

"Ich g[laube das  sollen TREP]pen sein"

Many potential interpretations:

- *spiral*
- *curled*
- *twined*
- *tight*
- *wounded*
- *circular*
- *upwards*
- *helical*

- *conchoidal*
- *twisted*
- *slender*
- *tight*
- *narrow*
- *ascending*
- ...

Slightly different understandings

- The understanding of a multimodal utterance depends on the informational evaluation of the gesture
- If the gesture is informationally evaluated to mean *helical*, then the utterance is about helical staircases, if the evaluation amounts to *tight*, then the utterance is about tight staircases, and so on.

Exceptional example

- The staircases example is exceptional
- Why?
- Its affiliate (remember?) is *staircases*, but gesture does not depict staircases directly
- Some additional step of coherence interpretation is needed

[2] A. Lascarides and M. Stone (2009). "A Formal Semantic Analysis of Gesture". In: J. of Semantics 26, 393–449

[3] H. Rieser (2008). "Aligned Iconic Gesture in Different Strata of MM Route-Description". In: LonDial 2008: The 12th Workshop on the Semantics and Pragmatics of Dialogue (SEMDIAL), 167–174

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- Gesture semantics suggested rhetorical relations[2] and lexical extensions[3]
- We will later follow a lexical but frame-based approach ($\rightarrow$ Lect. 5)

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Non-exceptional examples

mit ner Rosette  .. nen Rundfenster / *with a rosette .. a round window*

- Affiliate *rosette*
- Q: Which mode of representation?

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You know when they go on that wheel

- Affiliate *wheel*
- Q: Which mode of representation?

Non-exceptional examples

mit ner Rosette  .. nen Rundfenster / *with a rosette .. a round window*

- Affiliate *rosette*
- Q: Which mode of representation?
- A: representing

You know when they go on that wheel

- Affiliate *wheel*
- Q: Which mode of representation?
- A: drawing
- Circular axis-path defining feature of wheel, gesture directly depicts it

When informational evaluation?

- Often, gesture remain purely visual (see first lecture)
- When is a gesture informationally evaluated?

Three kinds of InfEval

There are (at least) three kinds of informational evaluation situations:

- gesture uptake[4],
- clarification interaction[5];
- the verbal description of meaning and function of gestures within gesture studies and gestural ($\neq$ gesture) semantics[6].

[4] M. Gullberg and S. Kita (2009). "Attention to Speech-Accompanying Gestures: Eye Movements and Information Uptake". In: Journal of Nonverbal Behavior 33, 251–277

[5] J. Ginzburg and A. Lücking (2021). "Requesting clarifications with speech and gestures". In: Proc. of the 1st Workshop on Multimodal Semantic Representations, 21–31

[6] e.g., P. Schlenker (2019). "Gestural semantics. Replicating the typology of linguistic inferences with pro- and post-speech gestures". In: Natural Language & Linguistic Theory 37, 735–784

Gesture uptake I

- Drawing response study[7]
- participants had to draw a situation that they saw described in a video of a speaker using speech and gesture.
- The speaker's gesture included a target gesture, that is, a gesture that displayed information not verbalized in speech (e.g., the direction of a movement).

[7] M. Gullberg and S. Kita (2009). "Attention to Speech-Accompanying Gestures: Eye Movements and Information Uptake". In: Journal of Nonverbal Behavior 33, 251–277

Gesture uptake II

- The authors found that the drawings only included the information exclusively gestured more often if the speaker gazed at the target gesture.[8]
- Hence, interlocutors themselves make a distinction between (mostly peripheral) seeing a gesture and interpreting a gesture (gesture uptake, or informational evaluation).

[8] M. Gullberg and S. Kita (2009). "Attention to Speech-Accompanying Gestures: Eye Movements and Information Uptake". In: Journal of Nonverbal Behavior 33, 251–277

Clarification interaction

(1) A: I think that should be  staircases

a. B:  ? [*B repeats A's gesture*]

b. B: Do you mean spiral staircases?

- B's two kinds of responses correspond to two different clarification strategies: confirmation questions and intended meaning requests.[a]
- (1a) is a nonverbal variant of verbal "Have I heard correctly? Did you say u", or "Do you mean u?", for some verbal constituent u.
- This reading does not seem to be available for (1b), however, which addresses the intended (linguistic) meaning z of the gesture: "Do you mean z as the content of γ?"

[a] On different types of clarification requests see Ginzburg (2012, §6.2).

Early gesture semantics and "gestural semantics"

- Translating annotation predicates into open formulas[9]

(2) (a) $rep(\text{HandShape } looseC) = hight(x,u) \wedge top(t,u) \wedge bottom(b,u)$

(b) $rep(\text{PathofWrist } ARC) = curved\text{-}side(s,u)$

(c) $rep(\text{WristLocat } ML > MF) = curved\text{-}side\text{-}left(sl,u,router)$

(d) $rep(\text{WristLocat } MR > MF) = curved\text{-}side\text{-}right(sr,u,router)$

(e) $rep(\text{Movement relative to other hand } Mirror\text{-}sagittal) = part(p1,u) \wedge part(p2,u) \wedge (p1 \neq p2) \wedge (p1 \otimes p2) = u$ [7]

- informal gesture glossing [10]

should TURN-WHEEL_  .
⇒ you should turn the wheel a bit but not much

[9] H. Rieser (2008). "Aligned Iconic Gesture in Different Strata of MM Route-Description". In: LonDial 2008: The 12th Workshop on the Semantics and Pragmatics of Dialogue (SEMDIAL), 167–174, 162

[10] P. Schlenker (2019). "Gestural semantics. Replicating the typology of linguistic inferences with pro- and post-speech gestures". In: Natural Language & Linguistic Theory 37, 735–784, 751

Informational evaluation

- Interlocutors at least sometimes interpret their gestures
- Gestures take part in clarification interaction
- Gesture researchers and semanticist use/postulate verbal descriptions to describe meaning and/or function of gestures

→ We need a place for the linguistic interpretation of gestures in semantic theory because it is a heuristic act (not always performed by the interlocutors).

Reversed denotation

Truth-conditional semantics

- "The bird is stealing icecream."
- $m = \lambda e[\text{steal}(e, x, y) \wedge \text{bird}(x) \wedge \text{icecream}(y)]$
- The assertion is true of an event s iff (abbreviates *if and only if*) $s \in m$.

"Bird Stealing Icecream" (Gerard Vlemmings, CC BY-NC-ND 3.0,

Truth-conditional semantics

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- The assertion is true of an event s iff (abbreviates *if and only if*) $s \in m$.
- One-place predicates (*bird*, *icecream*): functions from possible worlds (or world–time pairs, or situations) to entities ($[\![\cdot]\!]$).
- E.g., $[\![\text{icecream}]\!](s) =$ 🍦 (object x such that x is an icecream in s)
- Predicates exhibit a *word-to-world* direction of fit.

"Bird Stealing Icecream" (Gerard Vlemmings, CC BY-NC-ND 3.0,

World-to-word

- Speaking about what one sees, however, involves a relation f that exhibits a world-to-word direction of fit.
- given a perceptual input α, $f(\alpha)$ returns linguistic labels that classify α.

For example:

- $f($$) =$ icecream
- $f($$) =$ bird

Exemplification

- f can be thought of as an inverse over $[\![\cdot]\!]$
- Philosophy of language knows a candidate for such a relation f, namely Goodmanian exemplification.[11].

[11] N. Goodman (1976). Languages of Art. An Approach to a Theory of Symbols. Hackett Publishing Company, Inc.

Exemplification

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Toy example:

- The denotation of *green* is the set of three green objects.
- Given this, any object within the denotation can be used to exemplify, $\models_{\text{ex}}$, *green*.
  - $[\![\text{green}]\!] = \{$ $\}$
  - $\models_{\text{ex}}$ green

[11] N. Goodman (1976). Languages of Art. An Approach to a Theory of Symbols. Hackett Publishing Company, Inc.

Exemplification is too strong

- Exemplification *simpliciter* falls short of capturing iconic gestures, because gestures are not events but simulate events.
- Consider again the throwing gesture:

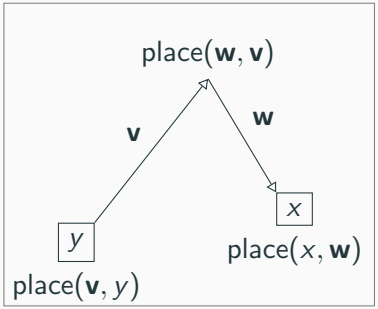
  You know when they go on that wheel and throw  *the dagger would you ever like to see that go wrong*?

- The speaker in is not actually throwing something.
- While he mimes handshape and movement of a throwing event, no dagger is leaving his hand.
- Trying to apply exemplification straightforwardly conflates gestures simulating actions with real-world actions.

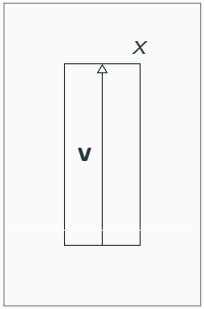
➔ We have to develop an extended notion of exemplification

Extended exemplification

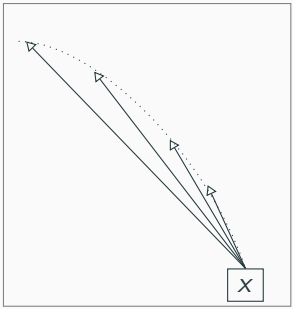
Background: Vector space semantics



place

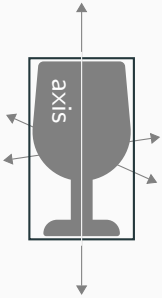


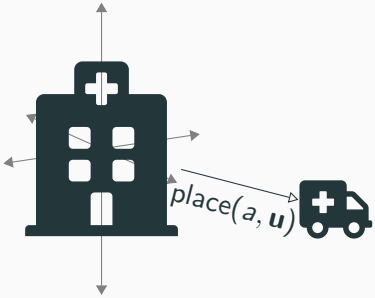
axis

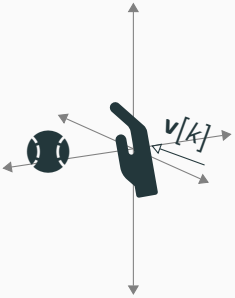


path

Background: Vector space semantics







Example: verbs

Motion verbs vary along two dimensions: manner and path. [12]

- The eigenmovement distinguishes motion verbs according to manner, regardless of the distance travelled:
- $\left\{ \begin{array}{c} \text{run} \\ \text{walk} \\ \text{stroll} \\ \text{saunter} \\ \ldots \end{array} \right\}$

- Translational movement gives rise to a path that distinguishes motion verbs irrespective of the manner of motion:
- $\left\{ \begin{array}{c} \text{run} \\ \text{detour} \\ \text{circle} \\ \text{criss-cross} \\ \ldots \end{array} \right\}$

[12] S. Engelberg (2000). Verben, Ereignisse und das Lexikon. Niemeyer

Verbs and paths

- The path component – the translational dimension of motions – is already covered by the vector denotations within the spatial model
- But what about the manner dimension?

➔ Psychophysic studies on the perception of biological motion[13]

[13] G. Johansson (1973). "Visual Perception of Biological Motion and a Model for its Analysis". In: Perception & Psychophysics 14, 201–211; G. Johansson (1976). "Spatio-Temporal Differentiation and Integration in Visual Motion Perception. An Experimental and Theoretical Analysis of Calculus-Like Functions in Visual Data Processing". In: Psychol. Res. 38, 379–393

Vector analysis of biological motion

Input

Vector analysis of biological motion

Input

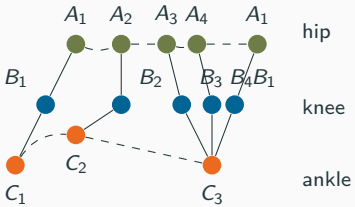
Carrier

Vector analysis of biological motion

Input

Carrier

Carrier movement

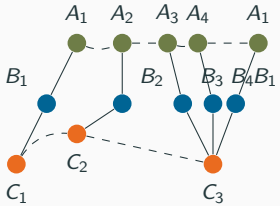


Vector analysis of biological motion

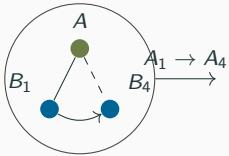
Input

Carrier

Carrier movement



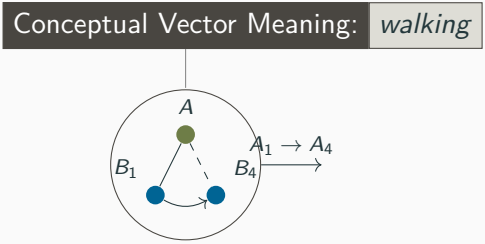
Abstract vector model



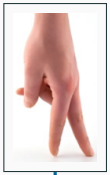
factoring out common movement shares

- "How can 10 points moving simultaneously on a screen in a rather irregular way give such a vivid and definite impression of human walking?" (Johansson 1973:204).
- An answer to this question was found in geometric analyses of the temporal stimulus pattern.
- Walking is characterized by two horizontal trajectories (due to hip and knee carriers) and an up-and-down sequence (ankle).
- Factoring out common movement shares, the kernel percept of a walking event is the conceptual vector model (CVM).
- If we observe something that looks like this vector model, we can classify it as *walking*.

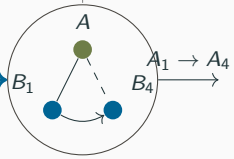
cvm and Gesture interpretation



cvm and Gesture interpretation

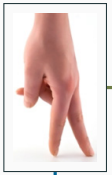


Conceptual Vector Meaning: *walking*



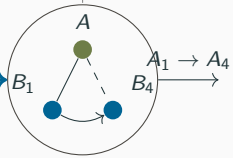
complies with

cvm and Gesture interpretation



is interpreted as

Conceptual Vector Meaning: *walking*



complies with

cvm and intensions

- Now singling out walking events is exactly what the meaning of the verb *walk* is supposed to achieve, and what is "pre-compiled" in model-theoretic semantics.
- Accordingly, we take the CVM to be a part of the intensional meaning of *walk*.
- Arguably, the lexical entry of any visuo-spatial expression comes with a CVM (cf. dual coding[14] and work in lexical semantics[15]).

[14] A. Paivio (1986). Mental Representations: A Dual Coding Approach. Oxford UP

[15] J. Pustejovsky and O. Batiukova (2019). The Lexicon. Cambridge UP

Enriched lexical entries

- Standard:

  $[\![\text{walk}]\!] = \lambda x.\lambda e[\text{walk}(e) \wedge \text{agent}(e, x) \wedge \exists \mathbf{v}[\text{place-path}(e, \mathbf{v})]]$

- New:

  $[\![\text{walk}]\!] = \lambda x.\lambda e[\text{walk-}\textsc{cvm}(e) = 1 \wedge \text{agent}(e, x) \wedge \exists \mathbf{v}[\text{place-path}(e, \mathbf{v})]]$

- CVM adds that the set of events E is such that each event $e \in E$ "looks like" the vector model encoded in walk-CVM.
- That is, CVM acts like a perceptual classifier known from computational semantics.[16]

[16] C. Kennington and D. Schlangen (2015). "Simple Learning and Compositional Application of Perceptually Grounded Word Meanings for Incremental Reference Resolution". In: Proc. of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing, 292–301; S. Larsson (2015). "Formal Semantics for Perceptual Classification". In: Journal of Logic and Computation 25, 335–369

Perceptual classifiers

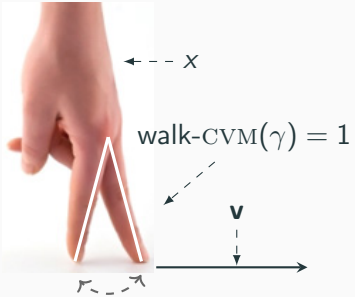
- The perceptual classifier σ associated with a word w maps perceptual input (from an object or a situation x) to the interval $[0, 1]$.
- $\sigma_w(x) \mapsto [0, 1]$
- The adaptation of intensional word meanings in a Montagovian framework to classifiers can be done straightforwardly:[17]
- $[\![w]\!] = \lambda x.\sigma_w(x)$

➔ Computational semantics provides a procedure for implementing the exemplification relation.

(More on computational semantics and ML in Lect. 4!)

[17] C. Kennington and D. Schlangen (2015). "Simple Learning and Compositional Application of Perceptually Grounded Word Meanings for Incremental Reference Resolution". In: Proc. of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing, 292–301

Example: *walking* again



- The gesture is compatible with *walk*, but fails for, e.g., *stagger*, *crawl*, *give*, *ride*, etc. because of different, incompatible CVMs.
- We propose a systematic elaboration of this sketch as the first part of a heuristic for gesture interpretation in semantic research in the following.

Extemplification heuristic

Minimal exemplification

- Consider *throw*, as in the throwing-a-dagger example.
- The extended lexicalized meaning of is:

  $[\![\text{throw}]\!] = \lambda y.\lambda x.\lambda e[\text{throw-CVM}(e) = 1 \wedge \text{agent}(e, x) \wedge \text{theme}(e, y) \wedge \exists \mathbf{v}[\text{place-path}(y, \mathbf{v})]]$

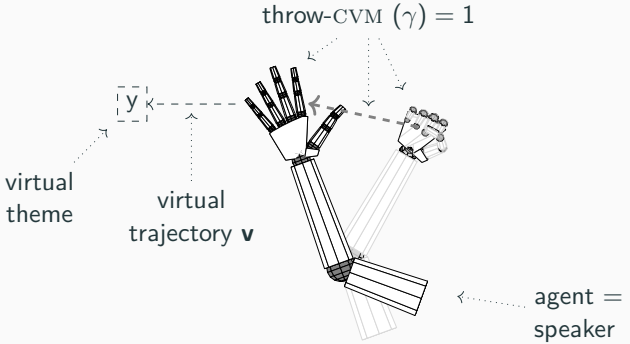
Gooodmanian:

- if there is a body movement which looks like throwing ('throw-$\text{CVM}(e) = 1$'),
- performed by x,
- and if there is something acted upon ('theme(y)') and that something is dislocated ('place-path($y, \mathbf{v}$)'; we abstract over time),
- we can classify this event e as a throwing event.

→ minimal exemplification

From exemplification to extemplification

- Abstraction to move from exemplification to extended exemplification, $\models_{\text{ext}}$, or extemplification (with a second "t") as a short coinage.
- The difference between exemplification and extemplification is that the latter acknowledges presupposed situational arguments.



(2) Extended exemplification as informational evaluation of a gesture

a. A gesture γ extemplifies a predicate p, $\gamma \models_{\text{ext}} p$, if $p\text{-CVM}(\gamma) = 1$ and γ is minimal wrt. p.

b. γ is minimal wrt. p iff there is a bijective mapping between (i) form features of γ, or (ii) visual, presupposed features of γ and the arguments of p.

c. If a. and b., that is, if γ exemplifies p, we can use p to informationally evaluate γ.

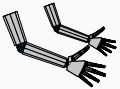
- Steps (2a,b) are to be brought about by the working semanticist, unless a computational classifier system is available.
- This is why (2) is a heuristic.

Applying the heuristic I

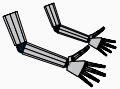
$[\![\text{throw}]\!] = \lambda y.\lambda x.\lambda e$
$[\text{throw-}\textsc{cvm}(e) = 1 \wedge$
$\text{agent}(e, x) \wedge$
$\text{theme}(e, y) \wedge \exists \mathbf{v}[\text{place-path}(y, \mathbf{v})]]$

- throw-$\textsc{cvm}(e) = 1$: gesture looks like throwing
- speaker/gesturer $\mapsto$ agent
- motion stop/opening hand $\mapsto$ virtual theme + path

Applying the heuristic II

- S. might bring her  dog.

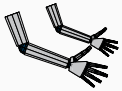
Applying the heuristic II

- S. might bring her  dog.
- $[\![\text{hold}]\!] = \lambda y.\lambda x.\lambda e$ $[\text{hold-}\textsc{cvm}(e) = 1 \wedge$ $\text{agent}(e, x) \wedge$ $\text{theme}(e, y)]$

Bijective iconic mappings:

- $\text{hold-}\textsc{cvm}(\gamma) \mapsto 1$ (the gesture looks like a holding posture)
- speaker/gesturer $\mapsto \text{agent}(e)$
- space between hands $\mapsto \text{theme}(e)$ (i.e., the theme remains virtual, or presupposed)

Applying the heuristic III

- S. might bring her  dog.
- Claim:[18]
  "S. might bring her large dog" /
  "If S. brings her dog, it will be large"

[18] M. Esipova (2019). "Composition and projection of co-speech gestures". In: Proc. of the 29th Semantics and Linguistic Theory Conference, 117–137

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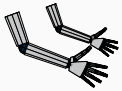
- S. might bring her  dog.
- Claim:[18]
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  "If S. brings her dog, it will be large"
- $[\![\text{large}]\!] = \lambda x[\text{standard}(\text{large}) \leq \text{large}(x)]$,
  where *large* is a measure function $\lambda x.\imath d.[x \textit{ is } d\textit{-large}]$ of type $\langle e, d\rangle$

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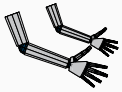
- S. might bring her  dog.
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Bijective iconic mappings:

- there is no large-CVM!
- (from Free Ride) distance $d \mapsto d$-*large*
- **?** $\mapsto$ standard (and it is unclear what to do with the agent)

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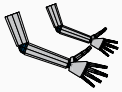
- S. might bring her  dog.
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Bijective iconic mappings:

- there is no large-CVM!
- (from Free Ride) distance $d \mapsto d$-*large*
- **?** $\mapsto$ standard (and it is unclear what to do with the agent)
- The standard is not an intrinsic property of (virtual or real) sizing actions.

→ *large* is not a fully visual property (as is already indicated by a lack of a CVM).

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Upshot

➔ Something like the InfEval heuristic is needed to avoid spurious gesture interpretations

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- The example is additionally deficient:
- The apparent affiliate (see Lect. 1 and 2) is *large* (i.e., "brings her large dog")
- However, if the largeness is important, then it should be focused rather than omitted.

Default extemplification

- Default: a gesture extemplifies its affiliate (good news: you do not have to think of all possible alternatives!)
- And the gesture often extemplifies the affiliate directly (e.g., throwing example)

→ The gesture remains informationally vacuous

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- Exceptions:
- I think that should be  staircases

Indirect extemplification

I think that

should be staircases

- The affiliate of the gesture is the noun *staircases*.
- *Staircases*, as hypernym, does not have a CVM.
- Different kinds of stairs are distinguished by form, however.
- Accordingly, the gesture can be construed as extemplifying a shape property (e.g., "helical")

➔ allows to infer a hyponym denoting a certain kind of stair.

- Generally: rhetorical connection R between InfEval p and affiliate β: $R(p, \beta)$[19]
- Simplest (and default) case: $R =$ identity
- Example: *throwing a dagger gesture* $R_{=}(\textit{throw}, \text{throw})$

[19] A. Lascarides and M. Stone (2009). "A Formal Semantic Analysis of Gesture". In: J. of Semantics 26, 393–449

Conditioned interpretation

Conditioned interpretation:
If gesture γ is informationally evaluated to mean p, then the whole multimodal utterance α is interpreted as $\alpha[R(p, \beta)]$.

If the meaning of the gesture is InfEvaled as

- *helical*, then the utterance is interpreted as "[...] that should be R(*helical*, staircases)"
- *tight*, then the utterance is interpreted as "[...] that should be R(*tight*, staircases)"
- *steep*, then the utterance is interpreted as "[...] that should be R(*steep*, staircases)"
- *upwards*, then the utterance is interpreted as "[...] that should be R(*upwards*, staircases)"

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How can one derive a relation R in case if $p \neq \beta$?

$\rightarrow$ Lect. 5