

The language of architectural diagrams

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COSIT 2019

DOI:
[10.4230/LIPIcs.COSIT.2019.17](https://doi.org/10.4230/LIPIcs.COSIT.2019.17)

Published: 01/09/2019

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):
Tenbrink, T., Conroy Dalton, R., & Williams, A. J. (2019). The language of architectural diagrams. In S. Timpf, C. Schlieder, M. Kattenbeck, B. Ludwig, & K. Stewart (Eds.), *COSIT 2019 : 14th Conference on Spatial Information Theory* (pp. 17:1-17:14). Dagstuhl Publishing. <https://doi.org/10.4230/LIPIcs.COSIT.2019.17>

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1 The language of architectural diagrams

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13 — Abstract —

14 Complex buildings frequently present a challenge to users' understanding, which may affect way-
15 finding as well as appreciation of the building's structure. In this paper we focus on the building's
16 *diagram*, a representation by the building's architect that captures its main 'idea'. Motivated by
17 the intuition that a building may be easier to understand if its conceptual diagram can be clearly
18 and easily described, we explored perceivers' descriptions of such diagrams' features. We asked
19 students of Language and students of Architecture to write about the buildings represented in a
20 variety of diagrams, and then repeated the task for photographs of the actual buildings. Using
21 Cognitive Discourse Analysis, we aimed to create a first qualitative exploration of the linguistic
22 and conceptual patterns that are associated with the perception of diagrams and images of com-
23 plex buildings. Among other factors, results show how perception of the diagram's meaning is
24 fundamentally affected by subject expertise. Linguistic patterns demonstrate the ways in which
25 written descriptions reflect observers' understanding and concepts of building representations,
26 providing a starting point for future studies which may address the possible relationship between
27 *verbalisability* of a diagram and the *legibility* of a building.

28 **2012 ACM Subject Classification** Empirical studies

29 **Keywords and phrases** visualisation, Cognitive Discourse Analysis, linguistic representation,
30 building legibility

31 **Digital Object Identifier** 10.4230/LIPIcs.COSIT.2019.23

32 **Acknowledgements** We thank the students at Bangor and Northumbria Universities who parti-
33 cipated in this study, and the architects who gave us permission to use their diagrams.

34 **1** Introduction

35 Have you ever stood in front of a complex public building, marvelled at its strange and
36 fascinating forms – and wondered how to make sense of it, locate the entrance or how to
37 find your way around inside? The building shown in Figure 1, Museu Paula Rego in Cascais,
38 might trigger such thoughts – impressive and perhaps a bit intimidating. How easy is it to
39 understand such buildings?

¹ The first two authors contributed equally to this paper.





■ **Figure 1** Museu Paula Rego, Cascais: Photograph and architectural diagram. Photograph, left, is copyright Chia Hsien Liao ('LeonL') and made available under a Creative Commons Attribution 2.0 Generic license. Diagram, right, copyright Eduardo Souto Moura and used with permission.

40 To represent our understanding of a complex building, how would we describe it in
 41 language? Words are, after all, our most commonly used tool to represent the world and
 42 our understanding of it. We use language to communicate our thoughts to others, and
 43 to express and develop our thought processes [5]. To some extent, people's concepts of a
 44 building can therefore be accessed by a close look at how they talk (or write) about them,
 45 i.e. by analysing verbal descriptions. In the context of architectural concepts, we might
 46 expect that the complexity of buildings and the concomitant understanding of them should
 47 be represented in linguistic description. Ultimately, we would also expect that a building
 48 that can be clearly understood (and hence clearly verbalised) should also be easy to use,
 49 or *usable* – applying a previous definition by Krukar et al. in which they suggest that "A
 50 building is usable when it allows the user to execute his/ her tasks effectively, efficiently and
 51 with satisfaction in the specified context of use." [14]. To a high extent, this will in practice
 52 depend on *navigability*, i.e. the ability to navigate to a destination within the building. This
 53 presupposes a degree of understanding of the building's structure, and thus relates to Lynch's
 54 idea of *legibility*: namely, "the ease with which its parts can be recognized and organized into
 55 a coherent pattern" [15].

56 Unique buildings such as the one shown in Figure 1 are designed by architects on the
 57 basis of an initial idea or concept, frequently represented in an architectural diagram (a
 58 notion we'll examine in some depth in Section 2), such as the one shown on the right. A
 59 diagram represents the architects', not the users', conceptualization – and it does so in
 60 visual form, not in language. Intuitively, there should be a connection: If a diagram and its
 61 associated building are easy to understand, they should also be relatively easy to put into
 62 words. However, the literature so far offers few insights as to how buildings, or their diagrams,
 63 are described intuitively by speakers with different degrees of architectural expertise. In
 64 this paper, we therefore start by exploring the ways in which various types of diagrams are
 65 verbalised by students of architecture and (for comparison) of language-related subject areas.

66 2 Architectural diagrams

67 A diagram can be thought of as a particularly specialist sub-class or type of drawing, in
 68 which a number of simplified or often symbolic depictions of real world objects are used to

Who?	Primarily architects—sometimes working alone, sometimes working in a team. Less used by non-architect members of the team although they may still be active participants in the process
What?	Feature set consisting of (from Do, 2001): 1. configurations 2. connections 3. shapes 4. orientations 5. physical form/s
Where?	Typically, but not exclusively, produced in the architecture studio, office or atelier (yet includes the 'back of napkin' sketch)
When?	During the design process, particularly at an early, more explorative stage
Why?	To explore and resolve ideas as well as to produce insights and inferences (Do, 2001). To negotiate between 'determinacy and indeterminacy' (Buchanan, 1992)
How?	Typically a freehand sketch on paper (or paper equivalent) using pen/pencil/charcoal etc.

■ **Table 1** Characteristics of architectural diagrams and their production ('diagramming')

69 represent complex relations between those objects. The use of diagrams, who produces them,
70 for what reasons, the features that they contain, and how they are used to communicate ideas
71 have been the focus of study in various ways: for example the classic studies on the nature
72 of representation by Peirce [17] and later Goodman [7] or on the use of diagrams in specific
73 contexts such as in scientific texts [8]. In this paper we focus on the very particular type of
74 diagrams, as used by architects. Architectural diagrams are typically produced during the
75 design process [16]; they may be the "key form of visual thinking within architecture" [2].

76 In Table 1 we outline a range of characteristics of architectural diagrams and their
77 production, which set them apart from the diagrams produced by other disciplines. Do [4]
78 argued that the main distinctive feature of architectural design diagrams, as compared to
79 diagrams in other domains, is "that the elements and spatial relations correspond to physical
80 elements and spatial relations in the architectural problem". While diagrams often depict real
81 world objects, it is only in architectural diagrams that the spatial relationships between those
82 real world objects are elevated to a level that gives them equal to, if not greater importance
83 than, the real world objects being depicted. This is because architecture is essentially a
84 spatial (and specifically a spatial configurational) art: as Hillier says, "The designer is in
85 effect a configurational thinker" [10].

86 Herbert [9] defined the architectural diagram as an analytic statement used to help the
87 architect solve a problem. Design problems, in general, and architectural design problems
88 specifically, are well-known examples of *wicked* or ill-formulated problems [18, 1]: problems
89 that have no definitive formulation, no stopping rules, can always have more than one solution,
90 and are unique in each case. This is aggravated by the constant need to negotiate between
91 determinacy and indeterminacy [1] - a process that may be supported substantially by the
92 use of diagrams. Somol [19] even suggested that, beyond a means of thinking, diagrams may
93 actually be "the matter of architecture itself"; and furthermore that the architectural diagram
94 has "seemingly emerged as the final tool... for architectural production and discourse".

95 This view of architectural diagrams acting as *more than* a mere representation aligns
96 very well with Hillier's view in his book, *Space is the Machine*, where he suggests "the idea
97 of architecture is at once a thing and an activity, certain attributes of buildings and a certain
98 way of arriving at them. Product and process are not, it seems, independent. In judging

99 architecture we note both the attributes of the thing and the intellectual process by which
 100 the thing is arrived at.” [10] If, in this sense, architecture is both a thing and an activity,
 101 then surely, by extension, the architectural diagram can be both an activity (tellingly often
 102 denoted by the verb ‘diagramming’ in architectural practice) and a thing, not only in of
 103 itself, but also as an interchangeable artifact standing for the, as yet, unrealised building.
 104 Even though some diagrams may never be realised as a building (which may make their
 105 significance debatable to some), they still represent their designer’s intent.

106 **3** From diagrams to language

107 If architectural diagrams are not merely a means for thinking about architectural design
 108 but have the potential to become the matter of architecture itself (c.f. Hillier’s combining
 109 of product and process), the question arises whether there is a direct relationship between
 110 the qualities of an architectural diagram and the qualities of the resultant building. Does a
 111 ‘clear’ (however defined) diagram produce a more ‘legible’ building in Lynch’s sense [15]?
 112 Does a diagram that is easy to understand result in a building that is also somehow clearer
 113 and hence more *usable* by the building’s inhabitant? Could there be a translation from a
 114 building’s diagram to its use that can be identified? To what extent would this depend on
 115 the observers’ expertise? Do architects understand a building’s diagram differently, or better,
 116 than non-trained observers? How does this relate to perceptions of the real building?

117 How could we begin to assess the comprehensibility or *clarity* of a diagram?² Hölscher
 118 and Dalton [11] asked architects and non-architects to gauge the complexity and perceived
 119 navigability of a set of buildings based on schematic floor plans. One interesting result was
 120 that building layouts that resembled commonly named-shapes (in this case a cross-shaped
 121 and a square-shaped layout) were judged very differently from the rest of the sample. These
 122 were prototypical examples of shapes with high “Prägnanz” (conciseness) as described in the
 123 literature on Gestalt psychology [13, 12]. Apart from representing highly familiar shapes for
 124 laypeople and architects alike, these layouts were also easily *describable*, since there existed
 125 common words to describe them. Thus, one measure of the *clarity* of a diagram might be
 126 how easily it could be described or ‘put into words’: how speakers *describe* diagrams may
 127 reflect what they *understand* about them. In this light, verbal descriptions of architectural
 128 diagrams might be key to the understanding of building complexity and, ultimately, usability.

129 So far, little is known about how diagrams are verbalised, and even less in the architectural
 130 domain. It is perhaps fair to say that the most relevant insights about the relation between
 131 diagrams and verbal description can be found in Barbara Tversky’s work [22, 23, 24]. Tversky
 132 consistently takes verbal descriptions as a representation of thought, and finds that linguistic
 133 expression and other representation media, such as sketches and gestures, correspond to each
 134 other systematically in terms of structure and essential elements or features representing
 135 crucial aspects of conceptualisation. However, clearly there are also limits to the kinds
 136 of aspects that can or will be verbalised with respect to a diagram or any other pictorial
 137 representation. Linguistic representations generally focus on relevance [20] in a discourse
 138 context, rather than aiming to be fully exhaustive.

² It is important not to confuse what we mean by clarity with Buchanan’s assertion that (architectural) problem solving is about relationship between ‘determinacy and indeterminacy’ [1]. It could be argued that many ‘clear’ architectural diagrams can simultaneously exhibit both aspects of determinacy and indeterminacy but that this remains quite independent from the clarity of a diagram, since, in our view, clarity reflects the explicitness of the architectural intent.

139 We will now present our study, which addresses the verbalisation of architectural diagrams
140 directly, by investigating linguistic patterns in descriptions of diverse diagrams and building
141 photographs, written by students with varying degrees of relevant subject knowledge.

142 3.1 Diagram selection and questionnaire design

143 In order to investigate the verbalisability of a diagram, we selected a consistent set of
144 architectural diagrams, representative of a wide range of styles and from a diverse group of
145 practicing architects, from a recent book on architectural sketches and diagrams³ by Chris
146 van Uffelen (2014) [25], as follows. We first identified a set of 37 diagrams that corresponded
147 to our notions of an architectural diagram (namely exploratory, ‘early-stage’ diagrams that
148 seemed to capture aspects of both determinacy and indeterminacy) but did not contain any
149 words. We analysed this initial set in terms of their attributes, noting if they appeared to be
150 drawn as a two-dimensional plan, section or elevation or as a three-dimensional view (or if
151 the viewpoint was unclear). We then recorded the number of occurrences of current drawing
152 elements, i.e. arrows, triangles, squares, rectangles, circles, ovals, spirals, curves/waves as well
153 as 90° and non-90° angles. We considered whether the diagrams included graphic techniques
154 such as hatching and shading and whether they included non-building symbols such as
155 people/figures and foliage/trees. Finally we noted if and when the building corresponding to
156 a diagram had been built in the real world.

157 From those buildings that had been constructed, we selected two that had a diagram
158 drawn in plan view, two with a diagram representing a section (or elevation) view, and two
159 with a diagram drawn in 3D. For each of these different iconic viewpoints we selected one
160 relatively simple diagram (i.e., the frequency of graphical elements in the feature set was
161 low, compared to the sample as a whole) and one more complex diagram (a relatively high
162 number of graphical elements in the feature set). The final set therefore consisted of 1 x
163 simple+plan; 1 x complex+plan; 1 x simple+section; 1 x complex+section; 1 x simple+3D
164 and 1 x complex+3D yielding 6 diagrams in total (see Figure 3 for all diagrams used in this
165 study⁴, and Figure 2 for photographs of the actual buildings).

166 A questionnaire (approved, separately, by Northumbria University’s Research Ethics
167 Committee and by the College of Arts, Humanities, and Business Research Ethics Committee
168 of Bangor University) was designed as follows. Prior to the main data collection, the
169 questionnaire’s purpose was explained and participants were asked to give their informed
170 consent. Following the main data collection, anonymized demographic information was
171 collected along with a set of questions designed to identify ‘visual thinkers’.

172 Section 1 of the questionnaire presented participants with each of the six buildings’
173 diagrams, in a sequential but randomized order, along with the instruction (repeated six
174 times): “Please look at this image below. Describe the building as it is depicted in the image,
175 in about three sentences.” In Section 2, the same diagrams were shown again (re-randomized),
176 along with the following instruction (again repeated for each diagram): “Please look at this
177 image below. Identify and describe which ‘elements’ (i.e. lines, shapes, forms, patterns etc.)
178 you can find in this image”. In Section 3, a photograph, randomly ordered, of each of the

³ *Sketch* is a more general term; in architecture it typically means a freehand representation of what is seen, or what might be seen: i.e., a translation from vision to paper. The architectural *diagram* is more specific: this is about relations between building spaces, forms and functions, and about exploring these via the medium of the drawing.

⁴ Copyrights for Figure 3: Top left: © Christian de Portzamparc Architect; Top middle: Fernando Romero, Mexico City, 2006; Top right: UNStudio Architects; Bottom left: copyright Daniel Libeskind; Bottom middle: Ana Rocha Architecture; Bottom right: Mr. Eduardo Souto Moura



■ **Figure 2** Building photographs. Top left: Cidade das Artes, Brasil: 2013 by architect Christian de Portzamparc; top middle: The Soumaya Museum, Mexico City: 2011 by Fernando Romero; top right: House Bierings, Utrecht: 2009 by Ana Rocha/Christian Richters; bottom left: Military History Museum, Dresden: 2011 by Studio Daniel Libeskind; bottom middle: Villa NM, New York: 2007 by Ben van Berkel; bottom right: Museu Paula Rego, Cascais: 2008 by Eduardo Souto Moura.

179 real buildings for which the diagrams had originally been drawn was presented,⁵ along with
 180 the following instruction (again repeated 6 times): “Here is one of the buildings that was
 181 shown as a drawing earlier. Please describe the real-world building in a few sentences.” Thus,
 182 for each of the six buildings, three written descriptions were elicited: two for its diagram and
 183 one for its photograph.

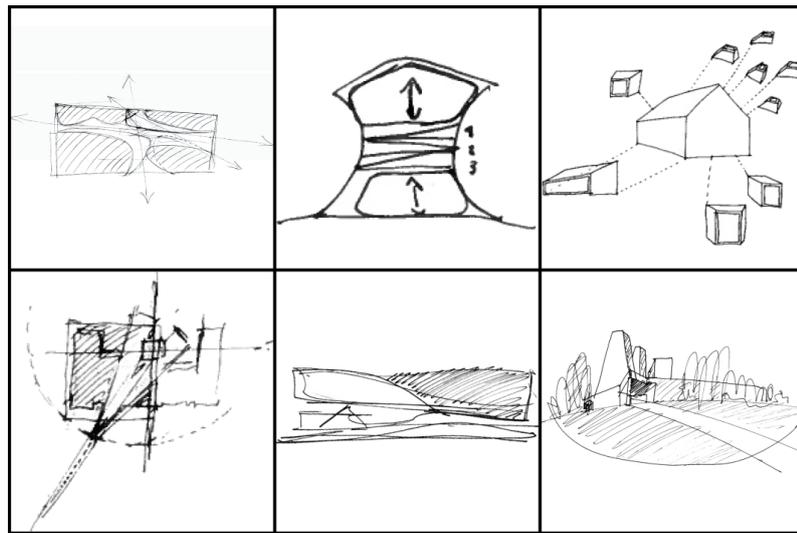
184 3.2 Participant features

185 Two sets of students were invited to participate in the study: students of language-related
 186 subject areas (such as Linguistics or English Literature, henceforth “Language student” for
 187 short) at Bangor University in Wales, and students of Architecture at Northumbria University
 188 in England. These two subject areas were chosen because the study addresses the *language*
 189 used in the context of *architectural design*, produced by participants whose background is
 190 relevant in distinct ways. The questionnaire was available for two weeks. The only incentive
 191 was a prize draw for an Amazon voucher; no other payments were made.

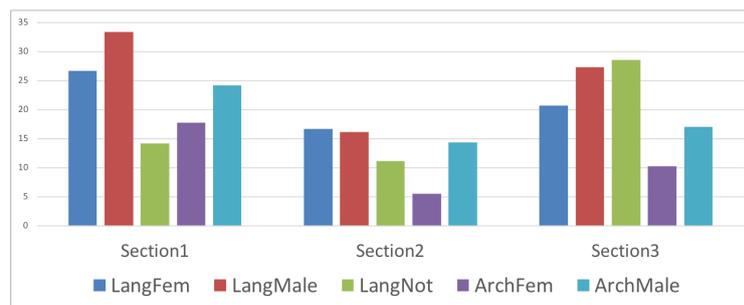
192 Of the 37 respondents, 22 were female, 14 male and 1 preferred not to say. For consistency
 193 of analysis, we eliminated one age outlier (64 years) from the final data set, as well as
 194 5 participants who were not native speakers of English, and 1 participant who failed to
 195 complete the questionnaire as asked. The final data set has 12 female, 5 male, and one
 196 gender-unidentified language students (mean age: 22.1; age range: 18-33), and 8 female and
 197 4 male architecture students (mean age: 22.7; age range: 20-25).

198 6 female and 2 male architecture students and 7 female, 2 male, and 1 gender-unidentified
 199 language student self-identified as visual thinkers. 7 female and 1 gender-unidentified

⁵ For copyright reasons, the pictures shown in Figure 2 differ slightly from the ones used in the study. Copyrights for Figure 2: Top left: Diego Baravelli; Top middle: Carlos Valenzuela; Top right: UNStudio Architects; Bottom left: Bernd Gross; Bottom middle: Ana Rocha Architecture; Bottom right: Chia Hsien Liao - LeonL. Top left and middle, bottom left and right are licensed under Creative Commons.



■ **Figure 3** Architectural diagrams used in the study, shown in the same order and configuration as the photographs of the corresponding buildings in Figure 2. Top row: simple; bottom row: complex. Diagrams on the left: plan views; middle: section views; right: 3D views.



■ **Figure 4** Mean word count in each questionnaire section. LangNot = gender-unidentified

200 language students (but no male) considered themselves to be artistic, and 7 female and
 201 3 male architecture students did so. Thus, while the data sets seemed fairly balanced in
 202 these respects, architecture students were (as might be expected) somewhat more likely to
 203 view themselves as visual thinkers and artistic. The same subject-related tendency was also
 204 reflected in the fact that all architecture students said they drew at least once a week or
 205 every day, whereas only four of the language students (3 female, 1 gender-unidentified) did
 206 so; 6 (3 males) said they could not remember when they last drew something, and 8 (2 males)
 207 drew once a month.

208 Subject-related and gender differences were also reflected in word count (see Figure 4).⁶
 209 Language students produced more words on average (female: 384.6; male: 460.4) than
 210 architecture students (female: 201.6; male: 322); variability of word count was reduced in
 211 female architecture students (range: 119-261) as compared to other groups (male architecture
 212 students: 151-748; female language students: 161-643; male language students: 137-805).

⁶ Words were counted semi-automatically in Microsoft Excel. Likewise, further analyses were supported by Excel's features as far as feasible.

213 **4 Cognitive Discourse Analysis**

214 Our aim was to gain insights into the concepts represented in the language in an explorative
 215 way, in light of various aspects of the study design: the two groups of students with their
 216 different subject expertise, how students described diagrams as opposed to photographs, the
 217 different building views and varying diagram complexity, and possible differences according
 218 to gender. None of these factors can be ignored, but they are too diverse to aim for any
 219 specific hypotheses based on inferential statistics, especially with unconstrained language
 220 production in an only loosely controlled data elicitation exercise, using a small sample size.
 221 Instead, we will present a qualitative analysis of linguistic patterns in our data following the
 222 methodology of Cognitive Discourse Analysis [21], which aims to identify conceptual aspects
 223 in discourse on the basis of systematic linguistic choices (beyond content).⁷

224 In the absence of specific hypotheses based on earlier literature we inspected the data to
 225 gain first insights about patterns in the responses that highlight the participants' underlying
 226 concepts systematically, in light of our motivating research question as to how architectural
 227 diagrams may be put into words and how verbalisability might relate to complexity and
 228 other features of the diagrams. To achieve systematic and objective annotation of our fairly
 229 large data set across various aspects, we then semi-automatically counted the occurrence of
 230 keywords in the following categories (emerging from the data, rather than predefined).

- 231 ■ **Peculiar:** Words indicating a sense of peculiarity (signalling challenges for legibility),
 232 namely *difficult, strange, unusual, unclear, peculiar, odd*
- 233 ■ **Possibility:** Indicators of tentative (i.e., possible rather than certain) interpretations:
 234 *seem, could, perhaps, appear, maybe, possible/possibility, ?*
- 235 ■ **Familiarity:** Words marking the respondent's familiarity with something (signalling
 236 legibility): *standard, traditional, exactly what, normal*
- 237 ■ **Structure:** Descriptions of structural elements (highlighting what kinds of structures
 238 were legible and verbalisable): *rectangle/rectangular, prism, triangle/triangular, square,*
 239 *boomerang, pyramid, box, hourglass, L-shaped, circle*
- 240 ■ **Function:** Mention of possible building functions (suggesting comprehension of the
 241 building in this respect): *public, school, theatre, museum, office*
- 242 ■ **Building/house:** Using the words *building* and *house* (reflecting conceptualisations of
 243 the building as a whole 3D entity)
- 244 ■ **Building parts:** Mention of any building parts in the house, such as *wall* or *window*
 245 (reflecting more fine-grained real-world concepts of the actual building functions)
- 246 ■ **Aesthetics:** Using terms that, in this context, indicate a sense of aesthetics (signalling
 247 usability and legibility in a different way): *organic, contrast, clean, feature*
- 248 ■ **Architectural:** Terms we identified in this context as architectural jargon, namely
 249 *circulation, intervention, extrude/extruding/intrude/intruding/extrusion/intrusion, ori-*
 250 *ent/orientation, void, mass, material, symmetry,* plus Adrian Forty's "key words in
 251 architecture" [6]: *character, context, design, flexibility, form, formal, function, history,*
 252 *memory, nature, order, simple, space, structure, transparency, truth, type, user.*

253 Note that there is no intention for these different categories to be equal in size, nor
 254 comparable in any sense to each other. They are, however, mutually exclusive.

⁷ To clarify, this approach does not exclude inferential statistics but only advocates it where feasible, which it is not in this explorative study.

5 Results

To gain a first intuitive impression of the language data, consider some exemplary descriptions:

Female language student, Section 1, complex, plan view (bottom left in Figure 3): "This looks like a birds-eye plan of a building. It is comprised of different shapes and would appear to have a triangular shaped building (or something) at the very top."

Male architecture student, Section 1, simple, section view (top middle in Figure 3): "Tall building, with dynamic shape. Two key large spaces with smaller intermediate floors. Long staircase covering entire width."

Male language student, Section 2, simple, 3D (top right in Figure 3): "The second drawing or outline in each dimension makes me think it has elevated surfaces."

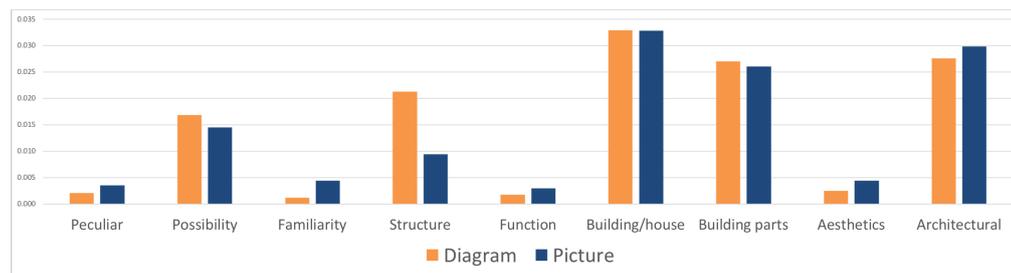
Female architecture student, Section 3, complex, section (bottom middle in Figure 2): "Bold design which uses cladding which appears cold. The glazed aspect of the design allows views to a feature of the designs context."

All of these answers are relevant to the question asked; the students are evidently making an effort to describe the features they see and recognize. It is also remarkable that all descriptions, regardless of whether they pertain to a diagram (Section 1 and 2 of the questionnaire) or a photograph (Section 3) take the building seriously in its final design, although some uncertainty can be detected, particularly in the language students' examples. Indeed, intuitively the architecture students' descriptions seem different in some way; this is an effect of subject knowledge that we aimed to capture in more depth.

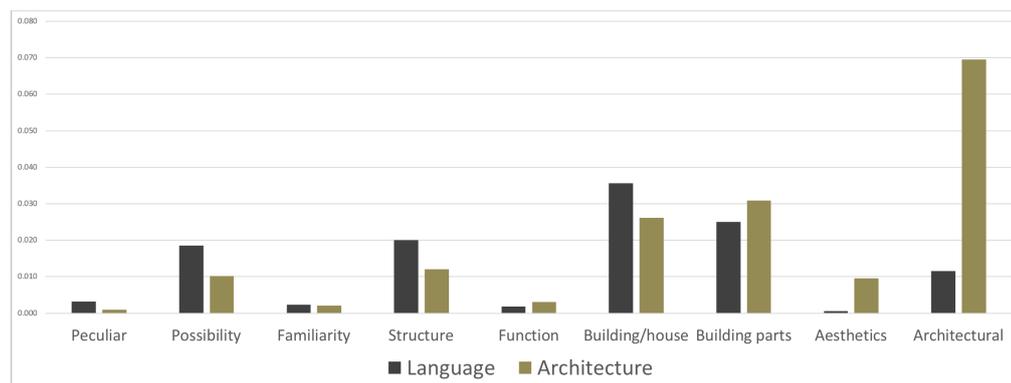
We found that female architecture students in Section 2, in particular, refrained from any kind of elaboration or speculation when describing the diagrams' elements, as reflected in a visible drop in the word count shown in Figure 4. Among those, a typical answer could be as short as "staircase" or "geometric cubes". Female language students' answers in Section 2 contrast sharply with this by being far more wordy and descriptive, and by frequently attributing function to form, as in "I see the circle which shows the area the building covers. Inside appears to be a shaded building, which could be the main focus, There appears to be a light sketch on the other side which could be the current building there." Again, the description seems tentative, trying to make sense of the diagram's features related to a *possible* building; in contrast, a female architecture student's crisp "Curved form floating above a void", like the other examples, seems to already describe *the building itself*.

Such observations motivated us to identify how linguistic indicators are spread throughout the data more systematically. We approached this by identifying patterns according to the various distinctions introduced by our design. Due to the high variability and diversity of patterns concerning word count reported above, our graphs show results in terms of percentages relative to total number of words in the relevant categories. Textual explanations provide raw numbers to demonstrate how often expressions actually occurred in the data. Patterns are described as they appear, with appropriate caution as to their significance; they may be suggestive but any stronger conclusions would require more controlled studies.

We start by noting that, in line with our initial intuition, descriptions of *diagrams* parallel those of building *photographs* concerning our chosen categories. As visualized in Figure 5, most categories are fairly equally represented in both types of representation. This is remarkable in light of the fact that participants were not asked to make a direct comparison and never saw a building's photograph side by side with its diagram. The differences that we do find in the graph intuitively make sense. Expressions of familiarity appear to be more frequent with pictures (N=15 out of 3380 words) than with diagrams (N=8 out of 6806 words); most of these (N=14 in total) point to the fairly traditional or standard form



■ **Figure 5** Comparing descriptions of architectural diagrams with pictures



■ **Figure 6** Results according to students' background

302 of House Bierings, Utrecht. In contrast, descriptions of structure are more frequent with
 303 diagrams (N=145; buildings: N=32). Thus, it appears that diagrams represent structures
 304 more clearly than the actual buildings do. Functions and aesthetic aspects, in contrast,
 305 appear to be somewhat more prominent with photographs.

306 Concerning our two participant groups, subject knowledge is most clearly evident through
 307 the architecture students' enhanced use of architectural terms (*circulation, intervention,*
 308 *mass, etc.*; N=174; language students: N=82). Beyond this, the graph shown in Figure 6
 309 suggests a range of further differences that together account, to some extent, for our previously
 310 observed impression that descriptions by architecture students seem different on the whole. In
 311 particular, language students tended to use more expressions of peculiarity (*difficult, strange,*
 312 *unusual* etc.; N=23) than architecture students (N=3), as well as expressions of possibility
 313 (*seem, perhaps* etc.; N=134; architects: N=30). Also, they referred to structures they
 314 recognised within the diagrams using non-architectural terms (*square, pyramid, hourglass*
 315 etc.; N=143) more than architecture students (N=34), and used the words *building* and
 316 *house* more frequently (N=258; architects: N=70). Relative to the overall number of words
 317 written, which was far lower in architecture students (2946 as opposed to 7240 written by
 318 language students), architecture students provided suggestions of possible functions (*public,*
 319 *school, museum, etc.*) more often (N=9) than language students (N=13), and they referred
 320 more often to aesthetic aspects (*organic, feature* etc.), (N=28; language students: N=4).

321 Next, we consider possible differences based on diagram complexity (see Figure 7). Against
 322 predictions, references to peculiarity seemed more frequent with simple diagrams (N=19) than
 323 with complex ones (N=7). However, expressions of possibility were somewhat more frequent
 324 in complex diagrams (N=90) than in simple ones (N=74), and expressions of familiarity
 325 (*standard, traditional, etc.*) appeared more often in simple diagrams (N=17) than in complex

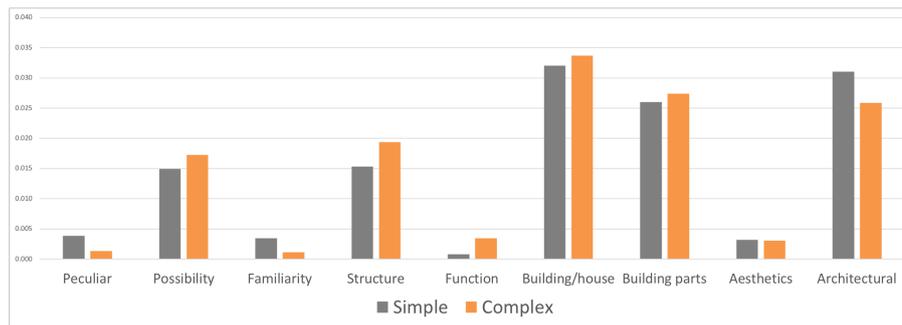


Figure 7 Results according to complexity of the diagram

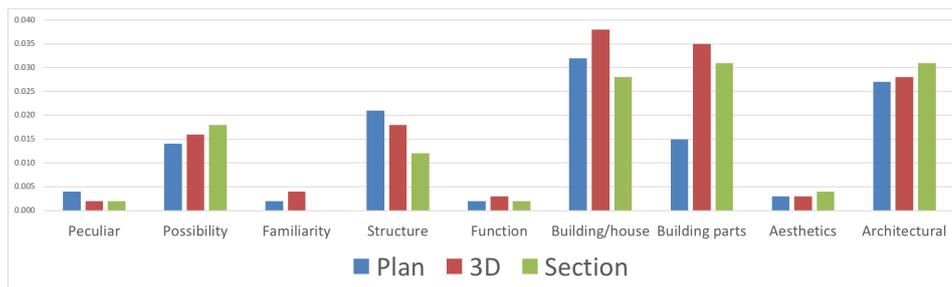


Figure 8 Results according to the type of diagram

ones (N=6). Suggestions of structure were less frequent with simple diagrams (N=76) than with complex ones (N=101), but the use of architectural terms appeared to decline with complexity (N=141 simple; N=116 complex).

The type of building view in the diagram (see Figure 8) appeared to affect language use only with respect to a few of our categories. References to the words *building* and *house* seemed more frequent in the case of a 3D diagram (N=136 as opposed to N=110 with a plan view and N=89 in the case of a section), suggesting that the idea of a building or house was more clearly visible. Structure seemed clearer with plan views (N=74) and 3D (N=66) than with section views (N=37). Plan views did not encourage recognition of specific building parts (N=51; 3D: N=125; section: N=96).

Finally, we can observe some tentative patterns concerning gender (Figure 9), beyond the word count differences noted in Section 3.2. Female participants tended to refer more to structures and used the words *building* and *house* more, and male participants used more expressions of possibility. (The gender-unidentified participant was excluded from

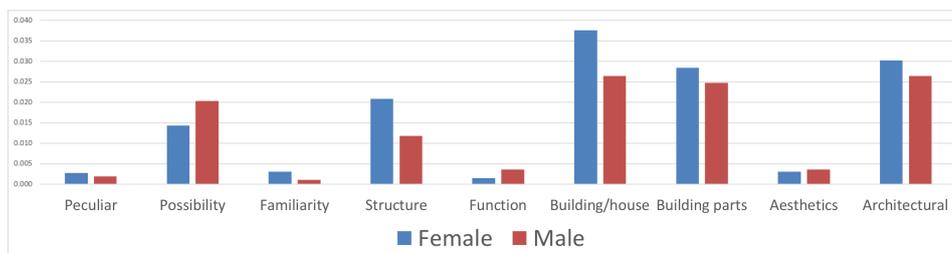


Figure 9 Results according to gender

340 this analysis.) We further noted that female architecture students were the only ones who
 341 used the words *North*, *East*, *South* or *West* in their responses (N=5, all in Section 1); the
 342 plan view diagrams may have invited this interpretation in the absence of actual compass
 343 information.

344 **6 Discussion**

345 We explored how architectural diagrams and their associated buildings are represented in
 346 language by people with different subject expertise, in light of various features of the diagrams.
 347 Results highlight a range of relevant observations that we hope will inspire future research.
 348 To start with, we note that this appeared a relatively easy task for both sets of students; in
 349 fact, the descriptions suggest that it may actually have been quite enjoyable⁸ - even though it
 350 was an atypical and unusual task for all participants, for different reasons. It is not surprising
 351 that language students produced a far higher mean number of words, despite their lack of
 352 subject knowledge: architects generally prefer the media of drawing and talking more than
 353 the act of writing. The fact that it nevertheless proved quite easy to elicit text descriptions
 354 of the diagrams is encouraging, as it suggests that this might be a fruitful way to investigate
 355 the purpose, intent and range of possible interpretations of architectural diagrams.

356 The high degree of correspondence between descriptions of diagrams and building pictures,
 357 in terms of our linguistic categories, aligns with the idea that in architecture, diagrams have
 358 a particular significance in that they are as much the subject of architectural endeavour as
 359 the buildings themselves (see Section 2). Indeed, the designer does not actually 'make' the
 360 building - that is built by others - and so the only artifact that is touched by the hand of
 361 the 'creator' are the drawings (which includes diagrams). It is therefore reasonable that the
 362 drawings should *stand for* the creative intent of the architect and should have a status that
 363 is equivalent (in this respect) to the building. To what extent descriptions of photographs
 364 correspond to descriptions of actual building views and, ultimately, building experience and
 365 usage, is a matter of future investigation.

366 Our diverse analyses suggest various effects caused by the nature of the diagram (such as
 367 its level of complexity or whether it shows the building in plan or section view), as well as
 368 the observers' gender. There are, for instance, some indications that complexity matters for
 369 the degree of understanding of a building and its diagram, as shown by differences such as
 370 references to *possibility* or architectural terminology. These avenues could be pursued further
 371 in the future, to assess the relevance of any such systematic effects for building legibility.

372 Beyond these patterns, it is interesting to consider the ways in which subject knowledge
 373 affects diagram (and photograph) interpretation. Unsurprisingly, architecture students made
 374 heavier use of what we classed as technical terminology. Note however that only a few of
 375 the 'architectural' terms in our list (see Section 4 above) are exclusively used in the realm
 376 of architecture. Others, such as *structure*, are everyday words whose meanings may change
 377 with expertise [6]. Compare one language student's formulation *flat looking rectangular*
 378 *structure* with an architecture student's *simple pitched roof structure with extruded mirrored*
 379 *window boxes*. For language students, the term *structure* serves as a generic label used
 380 to describe whatever elements they can find; for architecture students, the term itself is
 381 meaningful, specifying, within their context, the nature of architectural design with respect
 382 to the elements described. Similar effects have been found in previous studies; for instance,

⁸ To illustrate, here's a quote from the gender-unidentified language student, while describing the diagram of Villa NM in section 2: "An A-shape holding up a piece of pasta."

383 professional background can affect how simple words such as *back* and *end* are used when
 384 describing pictures [3]. Ultimately, such differences in language use subtly convey diversity
 385 in how speakers *think* about what they perceive in a picture or in a diagram.

386 The idea that expertise affects how people conceive of diagrams and associated buildings
 387 is further corroborated by various other differences we found between our participant groups.
 388 Altogether, the impression emerges that language students faithfully *describe what they see*,
 389 and use elaborate, cautious descriptions to speculate on possible meanings. For architects,
 390 in contrast, the simultaneous presence of both ‘determinacy and indeterminacy’ [1] is
 391 predominant; whilst the determinacy of the diagram shows the design-intent of the architect,
 392 it is the very indeterminant aspect of the drawing which permits diagrams to be ‘read’ on
 393 many different levels at the same time. Architecture students are being trained to produce
 394 such multi-level, multi-interpretable diagrams *for themselves*; this study indicates that this
 395 also contributes to the skill of interpreting the work *of others* in this way.

396 **7** Conclusions and Outlook

397 This study brought together two hitherto fairly disconnected perspectives: the significance
 398 of the architectural diagram as a representation of design ideas [19], and the significance
 399 of linguistic choices in representing a speaker’s perceptions [21]. The aim was to better
 400 understand how observers perceive architectural ideas as represented in diagrams.

401 Although explorative and qualitative in nature, a range of insights can be gained from this
 402 study. First, describing diagrams is feasible and yields meaningful linguistic data. Second,
 403 subject expertise (along with various further factors) affects descriptions in various ways; this
 404 highlights the different conceptualizations triggered by the visual information. It appears
 405 that the clarity of a diagram, or the ways in which it is understood, depends on who is
 406 interpreting it. It remains to be seen how these systematic differences in interpretation
 407 transfer to the real world building.

408 Supporting the idea of such a transfer, our third insight is that diagrams and photographs
 409 of buildings appear equally interpreted as representations of something real. The next step,
 410 accordingly, is to connect these representations to the actual buildings. Our ultimate aim
 411 (motivating this initial study) is to see whether a clear diagram (however defined) makes a
 412 more usable building (however defined), due to the legibility of its structures. This creates a
 413 clear need to take this work to the next stage: to relate diagram descriptions to navigation
 414 performance and further measures of the usability of the associated building.

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