Quantifiers in TIME and SPACE: computational complexity of generalized quantifiers in natural language
Szymanik, J.K.

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Index

Σ1-thesis, 39–41, 91, 125, 138
3SAT, 65
ARROWING, 82
Aczel, P., 172
Ajdukiewicz, K., 10
Al-Khwarizmi, 18
algorithm, 18–25
Andersson, A., 118
arithmetic of addition, see Presburger Arithmetic
Austin, J.L., 7
Büchi, J.R., 36
BALANCED COMPLETE BIPARTITE GRAPH, 80
Bartsch, R., 112
Barwise and Cooper (1981), 50, 54, 141
Barwise, J., 133, 137, 138
belief revision, 8, 9, 17, 37
Bennett, M.R., 112
van Benthem problem, 114
van Benthem, J., 12, 16, 20, 112, 153, 158, 159, 172, 173
bijection, 46
Blass and Gurevich (1986), 70
Burschick and Vollmer (1998), 118
Carnap, R., 8
categorization, 28
Chalmers, D., 28
Cherniak, Ch., 28
Chomsky, N., 34, 35
Church-Turing Thesis, 19, 23
Psychological Version, 26
Clark, R., 152
CLIQUE ≥q, 84
CLIQUE, 65, 83, 99
co-NP, 63
cognitive task, 25
collective lifts
determiner fitting operator, 116
existential modifier, 113
neutral modifier, 115
collective properties, 111
combined complexity, 69
complexity class, 61
captured by logic, 68
relativized, 64
compositionality, 172
comprehension, 6, 15, 18, 31
computational complexity, 20–25, 29
average-case, 31, 171
circuit, 171
parametrized, 31, 171
worst-case, 30
Concurrent Dynamic Game Logic, 172
context-dependence, 8
counter-free language, 59, 63
Cook, S., 22, 65

224
INDEX

Counting Hierarchy, 64, 124

data complexity, see model-checking
Dependence Logic, 47
descriptive complexity, 66
discourse, 36
   Representation Theory, 9
division of linguistic labor, 17
   van der Does, J., 113–115
Dynamic Epistemic Logic, 9

Edmonds, J., 22
   Thesis, 22, 24
Ehrenfeucht sentence, 47
Erdös, P., 81
Euclid, 18
everyday language, 39
expression complexity, 69
EXPTIME, 62
f-large, 86
Fagin’s Theorem, 39, 40, 68
finite automata, 56, 159
   acyclic, 158
   deterministic, 56
   nondeterministic, 55
Fixed-Parameter Tractability Thesis, 31
Frege, G., 10, 12, 13, 45, 47, 73, 110
Frixione, M., 25, 27
Gödel, K., 26
   games, 9
   algebra, 172
   and quantifiers, 171
dialogical, 14
   Ehrenfeucht-Fraïssé, 49
   equilibria, 172
   evolutionary, 9
   language, 10
   model constructions, 14
   signalling, 9
Garey and Johnson (1979), 22, 65, 80
generative capacity
   strong, 35
   weak, 35
Geurts, B., 54, 141
graph, 67
   bipartite, 80
Grice, P., 7
   conversational principles, 9
Hamn, F., 13, 17
Hella, L., 70
Henkin, L., 47
hierarchy of second-order formulae, 43
Hintikka’s sentence, 82, 130, 132
   conjunctional reading, 132
   strong reading, 131
   weak readings, 131
Hintikka’s Thesis, 131
Hintikka, J., 130
Hofstadter, D., 28
van Humboldt, W., 34
Independence Friendly Logic, 47
intractability, 21, 23
Invariance Thesis, 23, 27
isomorphism, 45
Kamp, H., 9
Kaplan, D., 8, 9
Karp, R., 65
Kolmogorov complexity, 34
Kontinen, and Niemistö, (2006), 68, 124
Kontinen, J., 120
Kripke, S., 10
van Lambalgen, M., 13, 17
Landman, F., 72
learning theory, 26, 54, 168, 174
Levesque, H., 28
Lewis, D., 9
Lindström, P., 45, 47
logic
   equivalent, 49
   extended by quantifier, 48
   first-order, 43
second-order, 43
LOGSPACE, 62
Lorenzen, P., 14
Lucas, J.R., 26

Makowsky and Pnueli (1995), 69
Marr, D., 25
levels of explanation, 25, 173
McMillan et al. (2005), 152
McNaughton and Papert, 36
meaning, 5, 6
as algorithm, 10–15, 17, 20
inferential, 17
referential, 15, 17, 129
synonymy, 14, 20, 22
model, 44
finite, 32, 67
encoding, 67
weak, 33, 172
model-checking, 11, 69
model-theoretic syntax, 35
Montague, R., 7, 13, 50
Moschovakis, Y., 13, 20
Mostowski and Wojtyniak (2004), 70, 78, 83, 138
Mostowski, M., 39, 45, 133, 136, 159
Musken, R., 13
negation normal sentence, 137
neural networks, 23
NEXPTIME, 62
NLOGSPACE, 62
NP, 62
NP-complete, 21
NP-hard, 21
NPSpace, 62
P-cognition Thesis, 27, 31, 39, 106
P=NP, 21, 63
Partee and Rooth (1983), 112
Penrose, R., 27
Peters and Westerståhl (2006), 72, 173
Piaget, J., 17
Polynomial Hierarchy, 64, 123
polynomial time
computable function, 65
many-one reduction, 65
PP, 64
pragmatics, 7, 9, 37
Pratt-Hartmann, I., 35, 36
Presburger Arithmetic, 159
PSPACE, 62
PTIME, 21, 62
Pumping Lemma
context-free languages, 60
regular languages, 58
push-down automata, 159
deterministic, 59
nondeterministic, 58
q-large, 84
quantifier
additive, see semi-linear
Aristotelian, 156
automata, 156
Boolean combinations, 50, 75
bounded, 87
branching, 47, 70, 77, 82, 88, 130
counting, 79
proportional, 78
cardinal, 157
CE, 52
clique, 83
collective reading, 110
complexity, 69
conservativity, 51, 117
collective, 118
cumulation, 74, 75
definability, 48, 49, 119
distributive reading, 110
divisibility, 157, 159
domain independent, 51
first-order, 153
generalized, 44–46, 69
satisfaction relation, 48
second-order, 118
Henkin, see branching
<table>
<thead>
<tr>
<th>Term</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher-order</td>
<td>153</td>
</tr>
<tr>
<td>iteration</td>
<td>73, 75, 135</td>
</tr>
<tr>
<td>Lindström</td>
<td>45, 46</td>
</tr>
<tr>
<td>measure</td>
<td>33</td>
</tr>
<tr>
<td>mighty</td>
<td>70</td>
</tr>
<tr>
<td>monadic</td>
<td>45, 154</td>
</tr>
<tr>
<td>monotonicity</td>
<td>52, 141</td>
</tr>
<tr>
<td>NP-complete, see mighty</td>
<td></td>
</tr>
<tr>
<td>NP-hard</td>
<td>70</td>
</tr>
<tr>
<td>partially ordered, see branching</td>
<td></td>
</tr>
<tr>
<td>persistence</td>
<td>53</td>
</tr>
<tr>
<td>polyadic</td>
<td>45, 72</td>
</tr>
<tr>
<td>polyadic lift</td>
<td>72</td>
</tr>
<tr>
<td>proportional</td>
<td>79, 101, 135, 158</td>
</tr>
<tr>
<td>Ramsey</td>
<td>81, 96</td>
</tr>
<tr>
<td>counting</td>
<td>83, 100</td>
</tr>
<tr>
<td>proportional</td>
<td>84, 101</td>
</tr>
<tr>
<td>relativization</td>
<td>51, 101, 103</td>
</tr>
<tr>
<td>resumption</td>
<td>74, 75, 88</td>
</tr>
<tr>
<td>second-order definable</td>
<td>33, 172</td>
</tr>
<tr>
<td>semi-linear</td>
<td>159</td>
</tr>
<tr>
<td>topic neutral</td>
<td>46</td>
</tr>
<tr>
<td>vectorization, see resumption</td>
<td></td>
</tr>
<tr>
<td>Ramsey Theory</td>
<td>81</td>
</tr>
<tr>
<td>reciprocal expressions</td>
<td>91, 145, 149</td>
</tr>
<tr>
<td>intermediate alternative reading</td>
<td>93</td>
</tr>
<tr>
<td>intermediate reading</td>
<td>92, 93</td>
</tr>
<tr>
<td>strong alternative reading</td>
<td>93</td>
</tr>
<tr>
<td>strong reading</td>
<td>92, 93</td>
</tr>
<tr>
<td>weak alternative reading</td>
<td>93</td>
</tr>
<tr>
<td>weak reading</td>
<td>92, 93</td>
</tr>
<tr>
<td>reciprocal lift</td>
<td>98</td>
</tr>
<tr>
<td>intermediate, 97</td>
<td></td>
</tr>
<tr>
<td>strong, 96</td>
<td></td>
</tr>
<tr>
<td>weak, 97</td>
<td></td>
</tr>
<tr>
<td>regular language</td>
<td>56, 63</td>
</tr>
<tr>
<td>Ristad, S.</td>
<td>36, 38</td>
</tr>
<tr>
<td>van Rooij, I.</td>
<td>28, 31</td>
</tr>
<tr>
<td>Russell, B.</td>
<td>110</td>
</tr>
<tr>
<td>SAT, 21, 65</td>
<td></td>
</tr>
<tr>
<td>satisfiability</td>
<td>21</td>
</tr>
<tr>
<td>Savitch, W.</td>
<td>63</td>
</tr>
<tr>
<td>Scha, R.</td>
<td>112</td>
</tr>
<tr>
<td>Schlenker, P.</td>
<td>149</td>
</tr>
<tr>
<td>semantics</td>
<td>7</td>
</tr>
<tr>
<td>construction</td>
<td>16</td>
</tr>
<tr>
<td>dynamic</td>
<td>14</td>
</tr>
<tr>
<td>dynamic turn</td>
<td>8</td>
</tr>
<tr>
<td>game-theoretic</td>
<td>14, 37, 47, 172</td>
</tr>
<tr>
<td>intensional</td>
<td>13</td>
</tr>
<tr>
<td>Sevenster, M.</td>
<td>14, 70, 78, 171</td>
</tr>
<tr>
<td>Skolem function</td>
<td>130</td>
</tr>
<tr>
<td>Stalnaker, R.</td>
<td>8, 9</td>
</tr>
<tr>
<td>Stockmeyer’s Theorem</td>
<td>68</td>
</tr>
<tr>
<td>Strong Meaning Hypothesis</td>
<td>94, 105</td>
</tr>
<tr>
<td>subset choice</td>
<td>28</td>
</tr>
<tr>
<td>substitution property</td>
<td>49</td>
</tr>
<tr>
<td>Suppes, P.</td>
<td>12, 16, 17</td>
</tr>
<tr>
<td>Tarski, A.</td>
<td>7</td>
</tr>
<tr>
<td>Tichý, P.</td>
<td>11, 12, 16</td>
</tr>
<tr>
<td>tractability</td>
<td>21, 23</td>
</tr>
<tr>
<td>Tsotsos, J.</td>
<td>28</td>
</tr>
<tr>
<td>Turing machine</td>
<td>11, 19, 26, 60</td>
</tr>
<tr>
<td>oracle, 63</td>
<td></td>
</tr>
<tr>
<td>type-theory</td>
<td>112</td>
</tr>
<tr>
<td>understanding, see comprehension</td>
<td></td>
</tr>
<tr>
<td>Väänänen, J.</td>
<td>69, 87, 102</td>
</tr>
<tr>
<td>Vardi, M.</td>
<td>69</td>
</tr>
<tr>
<td>visual search</td>
<td>28</td>
</tr>
<tr>
<td>Westerståhl, D.</td>
<td>32</td>
</tr>
<tr>
<td>Winter, Y.</td>
<td>113, 116</td>
</tr>
<tr>
<td>Wittgenstein, L.</td>
<td>10</td>
</tr>
<tr>
<td>working memory</td>
<td>153</td>
</tr>
</tbody>
</table>