Graphic and Symbolic Representation of Law: Lessons from Cross-Disciplinary Research

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This article summarises the author's research into the cognitive and linguistic reasons for common difficulties in comprehending law written in natural language, and the pros and cons of symbolic and graphical alternatives. Cross-disciplinary research identifies the dangers in these formats, and points to appropriate methods for applying visual techniques to legal content. The methods described in this article are presented in the hope of encouraging fellow legal educators to experiment with them to develop a greater understanding of their practical benefits.

The cry for plain English is still heard, but not so loudly in recent times. In the 1980's it was touted as the panacea for inscrutability in legislation and legal expression.[1] In its wake, fundamental changes were made to the way that legislation and law were written and presented. The fingerprints of those changes – finely structured and labeled provisions, preference for everyday, non-legalistic words, separate and generous dictionaries, bolded terms, etc. – are common in modern legislation[2] and consumer contracts.[3] Unfortunately, what is as common today as ever is the blank expression on the face of a student grappling with a rather elementary provision, or the more hostile look of a client who just 'doesn't get it'.

Similarly, graphic and pictorial formats have been promoted as promising solutions to the difficulties of understanding law,[4] but again the results are less tangible. While it is common to see features like concept maps and flow charts within course materials and even legislation,[5] in the educational arena any consequent improvement in legal problem-solving is elusive.

This article summarises the author's research into the cognitive and linguistic reasons for common difficulties in comprehending law written in natural language, and the pros and cons of symbolic and graphical alternatives. It also documents some visual methods that have been implemented with some success in a modern organisational setting.

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[1] Robyn Penman, 'Plain English: Wrong Solution to an Important Problem' (1992) 19(3) *Australian Journal of Communication* 1; Australian Language and Literacy Council, *Putting it Plainly: Current Developments and Needs in Plain English and Accessible Reading Materials* (Canberra : Australian Government Publishing Service, 1996), 4, 13-14.

[2] Hilary Penfold QC, 'When Words Aren't Enough: Graphics and Other Innovations in Legislative Drafting'. (Paper presented at the Language and the Law Conference, University of Texas, Austin, 6-8 December 2001); John Kimble, 'Answering the Critics of Plain Language' (1994-5) 5 *The Scribes Journal of Legal Writing* 51, 56-59.

[3] Australian Language and Literacy Council, above n 1, 13-14.

[4] Andrew Lodder and Michael Bachas, 'Content Delivery in Australian Law Schools' (Discussion Paper, Australian Law Students' Association, 2004), 2, par. 3.2.6; Ian Ireland, 'Transforming the Way We Record and Access Law' (2002) 9(3) *eLaw Journal: Murdoch University Electronic Journal of Law*. See also David Perkins, 'Teaching for Understanding' (1993) 17(3) *American Educator: the Professional Journal of the American Federation of Teachers* 8, 28-35, par.3.

[5] Penfold, above n 2.

1. What are we Trying to Teach?

It is commonplace in education to categorise learning goals as either *retention* (of knowledge) or *transfer* (application of knowledge to the solution of novel problems).[6] This dichotomy does not readily analogise to teaching of the law.

When teaching statute law, for example, we do not think in terms of trainees memorising provisions. In fact, we urge them on any significant problem to refer to the Act, rather than work from memory. Experts do not know the Act off by heart, nor do they want to. Statutes do not contain static data, but rather logical formulas to be applied to 'known facts'. Nor is there any direct match for the skill of inference generation sought by teachers of science.[7] Inference generation may well be important to interpreting evidence, but in a legal educational context the facts are normally expressed as 'given'.

This might suggest that learning to apply the law should be relatively easy, but experience shows otherwise. Restricting the problem space to 'known facts' merely highlights issues that arise from the expression and interpretation of law – the problems faced particularly by law students and government officers who administer legislation, but also by ordinary people who encounter the law in their daily lives.

2. The Nature of the Law

Law is a system of rules stipulating legal outcomes governed by conditions. The outcomes and conditions are all propositions of some form. The ultimate outcomes are rights (effectively powers) or obligations (either duties or liabilities),[8] but particular provisions may prescribe the conditions for an intermediate outcome, such as a legal status or classification. For example, to qualify for a first home owner's concession (a right), one must satisfy conditions that define a first home owner (an intermediate classification). The conditions may be *conjunctive* ('and' clauses) or *disjunctive* ('or' clauses).

Both common law and statutory provisions are of the same ilk, though statutory interpretation is more literal than common law. Common law poses the preliminary hurdle of ascertaining its content. Its precise form is often elusive and may depend on patterns of meaning derived from multiple cases that do not gel into a cogent continuum. Sometimes the same principle will be stated in different words in different judgments.[9] Once formulated, however, the common law ultimately prescribes rules and principles governed by conditions, just as statutes do.

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[6] Kirsten Butcher, 'Learning From Text With Diagrams: Promoting Mental Model Development and Inference Generation' (2006) 98 *Journal of Educational Psychology* 182; Robert Carlson, Paul Chandler and John Sweller, 'Learning and Understanding Science Instructional Material' (2003) 95 *Journal of Educational Psychology* 629.

[7] Butcher, above n 6; see generally Janice Glasgow, N Hari Narayanan and B Chandresekaran (eds), *Diagrammatic Reasoning: cognitive and computational perspectives* (Cambridge: AAAI Press, 1995).

[8] Reed Dickerson, *The Fundamentals of Legal Drafting* (2nd ed, Boston: Little, Brown & Company, 1986), 3; Robert Martineau, *Drafting Legislation and Rules in Plain English* (Saint Paul: West Publishing Company, 1991).

[9] Stephen Mason, 'Law-making, Drafting and Law Reform' in David St L. Kelly (ed) *Essays on Legislative Drafting* (Adelaide : Adelaide Law Review Association, University of Adelaide, 1988), 111.

3. The Languages of Logic

In mathematics, such a system is called relational clausal logic.[10] Mathematicians wouldn't dream of attempting to express strict logic in natural language, as natural language is inherently ambiguous and prone to redundancy. In maths, a rule of clausal logic would more likely be expressed like this:

first_home_owner(X) :-
(adult(X) ; age_dispensation(X)),
no_of_previous_homes(X, 0),
co-owner(X,Y),
no_of_previous_homes(Y, 0).

age_dispensation(X) :-
application(X, commissioner, form1),
result(application(X, commissioner, form1), success).

And so it would go on, elaborating the meaning of arbitrary expressions like 'no_of_previous_homes', 'co_occupant', 'application' and even 'adult' by further rules, just as such terms are refined and defined in law to reduce their ambiguity.

Relational clausal logic employs its own language of symbols: colon + dash (:-) means 'if', a comma means 'and' and a semicolon means 'or'. The outer parentheses around 'adult(X); age_dispensation(X)' are required to ensure those terms are evaluated before the 'and' clauses – like bracketing in an arithmetical expression.

This language has the apparent virtues of precision and lack of redundancy, but without special training and practice, no one can understand it. To the extent that it conveys any intuitive meaning, that meaning is derived from the natural language embedded in it, which is deceptive in that the words are purely arbitrary and need not bear their natural meanings. There is no rule of logic to the effect that the term 'age_dispensation', for example, must have anything to do with age or dispensation, and to the extent that it is implied, any correspondence with its English meaning is wholly undefined.

Mathematicians also use algebras to simplify logic, but the traditional algebra for logic (Boolean algebra) is unable to fully represent conditional expressions (i.e. 'if' clauses). However, it could list the conditions for a first home concession like this:-

(A v B) ^ C ^ D ^ E

where:-

A = X is an adult
B = X has an age dispensation
C = X has not previously owned a home
D = Y is a co-owner with X
E = Y has not previously owned a home

[10] Strictly speaking, it is *definite* relational clausal logic, since the outcomes are singular – only one outcome is prescribed by a particular set of conditions. In indefinite clausal logic, a set of conditions can prescribe alternative outcomes.

The symbol '^' means 'and' and the symbol 'v' means 'or'. The symbol ¬ is also available to mean 'not'.

Algebras can be a useful means of simplifying expressions by transforming their structure, but any real meaning attaching to them derives not from the mathematical expression, but from the legend underneath that defines the variables in natural language, with all the ambiguities that entails. As such, algebra is not a solution to ambiguity and uncertainty, but it may simplify the search for valid alternative expressions. For example, algebraic rules tell us that these two expressions are the same:-

¬ (A v B)
¬ A ^ ¬ B

In a natural language context, particularly when embedded in a more complex set of provisions, one version may be easier to understand than the other. Algebra could automatically point to these alternatives, without the need for logical re-analysis.

Although the potential uses of algebra in law are beyond the scope of this article, it is worthwhile noting that algebraic transformation could well reduce the cognitive problems of branching and lack of closure discussed later in the article. More complex application of algebraic rules demonstrates, for example, that a series of propositions can be translated into a series of conjuncts (conjunctive normal form – CNF). When handled correctly, conjunctive propositions tend to 'close off' meaning, while disjuncts often leave meaning hanging beyond our cognitive capacity. Cognitive 'overload' may also result from excessive branching depth, which could be cured algebraically by translating propositional structures into less deeply nested forms.

4. Logic and Natural Language

Cognitive scientists over several decades have studied the cognitive mechanisms of logical reasoning, using problems expressed in the plainest of English with the simplest of conditions. Typically, such studies present subjects with two or three propositions and a conclusion (or ask them to draw a conclusion), which they must assess as valid, invalid or unverifiable. These are examples:-[11]

Series problem:-

John is taller than Henry.
John is shorter than Mary.
Mary is shorter than Billy.
Is Billy shorter than Henry?[12]

Syllogism:-

No archers are bowlers.
Some bowlers are chefs.
Conclusion: Some chefs are not archers.[13]

[11] Taken or adapted from: Gray, *Psychology* (3rd ed, New York: Worth Publishers, 1999), 383; Thad Polk and Allen Newell 'Deduction as Verbal Reasoning' (1995) 102 *Psychological Review* 533, 536; P N Johnson-Laird and Ruth Byrne, 'Conditionals: A Theory of Meaning, Pragmatics, and Inference' (2002) 109 *Psychological Review* 646.
[12] No. Billy is taller than everyone mentioned.

Conditional:-

If a card has an 'A' on the front, it has a '2' on the back.
The card does not have a '2' on the back.
Conclusion: The card does not have an 'A' on the front.[14]

The clearest result of this research is that untrained people do not use logic to solve logic problems, at least not when the problems are presented in natural language.[15] Participants show biases, inconsistencies and incompetencies that would not be generated by a sound rule-based logic mechanism. Polk and Newell[16] recount several relevant effects.-

1. The *difficulty effect*
    - The average participant makes many errors, often around 50%.
2. The *atmosphere effect*
    - If either premise is negative, most responses are negative. Otherwise, most are positive.
    - If either premise is particular (e.g. 'Some archers are …' as opposed to 'All archers are …'), most responses are particular; otherwise most are universal.
3. The *conversion effect*:-
    - Many erroneous responses would be correct if the converse of a premise were assumed to be true. For example, 'If A then B' is interpreted to also mean, 'If B, then A'.[17]
4. The *figural effect*:
    - If the premises all have the same subject, that tends to be the subject of the conclusion.
5. The *belief bias effect*:
    - Participants are more likely to generate and accept as valid a conclusion that they believe is true than one they believe is false, independent of the true logical status.

The cognitive process of 'reasoning' with words reflects a pattern like this:-

- The reader projects a provisional mental representation, or model, based on an initial scan of the propositions. In deductive reasoning, this model corresponds to a possibility.[18]

[13] True. The chefs who are bowlers are not archers.
[14] False. A card that has 'A' on the front will have '2' on the back, but the converse is not necessarily true – a card with '2' on the back may not have 'A' on the front.
[15] Johnson-Laird and Byrne, above n 11, 646-7, 674.
[16] Polk and Newell, above n 11, 536.
[17] Strictly speaking, this is the converse; but it is equivalent to 'If not A, then not B', which may be the actual form of the erroneous inference.

- The reader then tests the model for consistency with the consequent (outcome) proposition, possibly by searching for counter-examples.[19] If there is apparent consistency, he/she adopts the model as correct. If there is inconsistency, he/she re-models it, either by augmenting or replacing the original, and re-tests it.

- If a satisfactory answer is not hit upon, he/she continues this process until a 'give-up' point is reached,[20] at which time he/she may respond intuitively – e.g. by guessing.

There is some controversy about how these models are generated,[21] but experimental results strongly suggest that people do not harness an innate mechanism equipped with the laws of logic. The models are constructed from perception, imagination, or the comprehension of discourse, and may be visual or abstract.[22]

This pattern of reasoning ought not come as a surprise to legal educators. Evidence consistent with it can be routinely generated by quizzing students on how they arrived at a particular solution to a legal problem (whether correct or incorrect). Their response will rarely focus solely on the precise words of the provision under scrutiny or describe a stepwise, deductive process. More often it will be infected with statements like:- 'I thought they were driving at this', or 'I thought the section was trying to do this'. When directed to the logical steps of a provision, students frequently peter out somewhere in the middle (the 'give-up' point), despite having unlimited time for completion.

Evidence of mental modelling can also be found in course feedback calling for more factual examples. Realistic factual scenarios have been found to enhance transfer of problem-solving skills in non-legal fields. However, in legal training we find that their use too often corresponds with an abandonment of logic in favour of factual pattern-matching, in which the trainee looks for factual resemblances between a scenario with a known (or supposed) correct answer and the problem scenario. A trainee succinctly described the practice in this feedback suggestion: 'Tell me all the fact situations and I'll memorise them.'

The characteristics of mental modelling make it ill-suited to solving logical problems. It is a constructive process founded on trial and error. A standard psychological text expresses it in this way:

> In everyday experience we generally take a pragmatic rather than a literal or analytical approach to understanding what another person has said. We take into account not just the words we hear but the context in which we hear them and implicit assumptions about the

[18] Johnson-Laird and Byrne, above n 11, 653; Polk and Newell, above n 11, 555.
[19] Walter Schroyens and Walter Schaeken, 'Deductive Rationality in Validating and Testing Conditional Inferences' (2008) 62 *Canadian Journal of Experimental Psychology* 163. cf. Polk and Newell, above n 11, 555.
[20] Polk and Newell, above n 11, 534.
[21] See generally, Polk and Newell, above n 11; Michael Harm and Mark Seidenberg, 'Computing the Meanings of Words in Reading: Cooperative Division of Labor Between Visual and Phonological Processes' (2004) 111 *Psychological Review* 662; Pierre Barrouillet and Caroline Gauffroy, 'Mental Models and the Suppositional Account of Conditionals' (2008) 115 *Psychological Review* 760.
[22] Johnson-Laird and Byrne, above n 11, 647.

> speaker's motives and verbal habits. If a stranger approaches you on the streets and asks, 'Do you know how to get to Market Square?', you do not respond, 'Yes, thank you', which would be appropriate if you took the stranger's words literally.
>
> Deductive logic problems on reasoning tests require us to use the literal meaning of the words employed, and that may often be the limiting factor in our ability to solve such problems … Only logicians and lawyers attend regularly to the literal meaning of words, and that is why logic problems and legal contracts often seem awkward and hard to understand.[23]

The constructive process is characteristic of language generally, not just reading:

> In normal speech, people never say everything that can be said. Instead, they say just enough for the listener to reconstruct the intended meaning in the given context. According to Merlau-Ponty (1964),[24] 'The totality of meaning is never fully rendered: there is an immense mass of implications, even in the most explicit of languages; or rather, nothing is ever completely expressed, nothing exempts the subject who is listening from taking the initiative in giving an interpretation'.[25]

When language is employed as a specification of logic, rather than to communicate a state of affairs or a narrative, this taking of the 'initiative' has a falsifying effect.

5. Problem-Solving Schemas

Other research describes the difference between expert and novice approaches to problem-solving. Experts solve problems by retrieving from memory domain-specific schemas. A schema is a mental construct permitting problem-solvers to categorise problems according to solution modes.[26] The schema generates a procedural path to a solution, probably automatically (unconsciously), obviating the need to consciously search for the next step.[27] Experts therefore move forward step by step towards a solution, whereas novices focus on surface structures, working backward from a tentative solution, attempting by trial-and-error to match the problem state.[28] This search process is cumbersome and error-prone.[29]

Research on schemas strongly suggests that *worked examples* are better for learning than the approach of 'throw-them-in-at-the-deep-end-and-see-if-they-drown'.[30] Beginners presented with full-scale problems teach themselves the wrong schemas, which prove hard to shift later. Worked examples, on the other hand, demonstrate not only the correct answer, but also the correct way to get there. This must be distinguished from factual pattern-matching, which is a form of guesswork typical of novices. The skill learned in a worked example is more readily transferable to similar problems, and the learning is more incremental.

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[23] Gray, above n 11, 394.
[24] Maurice Merlau-Ponty, *Consciousness and the Acquisition of Language* (Eavanston: Northwestern University Press, 1964), 29.
[25] John Sowa, *Conceptual Structures: Information Processing in the Mind and Machine* (New York: Addison Wesley, 1984), 127.
[26] John Sweller et al, 'Cognitive Load as a Factor in the Structuring of Technical Material' (1990) 119 *Journal of Experimental Psychology: General* 176.
[27] John Sweller, 'Cognitive Technology: Some Procedures for Facilitating Learning and Problem Solving in Mathematics and Science' (1989) 81 *Journal of Educational Psychology* 457, 458.
[28] Sweller et al (1990), above n 27.
[29] Sweller (1989), above n 27.
[30] Sweller (1989), above n 27, 463.

The theory of schemas is sometimes presented in opposition to the mental-model theory referred to earlier, but one could as well argue that the constructive, mental-modelling approach *is* the expert schema for language when it is used as a vehicle for communicating information or narrative. Cognitive research suggests that the weakness of the reading mechanism for conditional reasoning is its reliance on trial-and-error modelling, rather than *procedural* schemas.[31]

The potential adverse effects of the reading reflex are starkly highlighted by studies of mental arithmetic involving single operations on numbers less than ten. Campbell[32] showed that people make significantly fewer errors when presented with an arithmetic problem written in symbols (e.g. 9 + 1) than if the same problem is presented in words (e.g. 'nine plus one'). A recent follow-up study showed that the same effect is *not* found when the sums are spoken, rather than written in words.[33]

If the reading mechanism can disrupt near-kindergarten level arithmetic, even when the words so clearly represent an arithmetic problem, how much harder is it when:-

- the calculation is not one of arithmetic, in which we have training from childhood, but logic, in which we have no formal training;
- the written form more closely resembles a narrative than a math problem; and
- the calculations are much more complex than a single arithmetical sum?

6. Problems of Cognitive Load

Conscious thought takes place in what is called 'working memory', sometimes known as 'short-term memory'. Contrary to popular conceptions of short-term memory as a store for a multiplicity of memories that last a few hours or days, working memory has a capacity of only a few discrete 'chunks' of information, which endure for just a few seconds unless regularly refreshed by rehearsal.[34] Due to limited capacity, working memory must constantly retrieve and flush out data to engage in the most basic thought processes. This reflects a problem known as *cognitive load*.

Cognitive load is perhaps the primary limiting factor in learning, understanding and mental problem-solving, whether scientific, mathematical, legal, logical, or otherwise.[35] Logical rules, however expressed, present significant challenges to our cognitive powers.

[31] Sweller (1989), above n 27, 460. See also Polk and Newell, above n 11, 534-535.
[32] Jamie Campbell, 'Architectures for Numerical Cognition' (1994) 53 *Cognition* 1; Jamie Campbell, 'The Surface Form x Problem-Size Interaction in Cognitive Arithmetic: Evidence Against an Encoding Locus' (1999) 70(2) *Cognition* B25.
[33] Arron Metcalfe and Jamie Campbell, 'Spoken Numbers Versus Arabic Numerals: Differential Effects on Adults' Multiplication and Addition' (2008) 62 *Canadian Journal of Experimental Psychology* 56, 60.
[34] George Miller, 'The Magical Number Seven Plus or Minus Two: Some Limits on Our Capacity for Processing Information' (1956) 63 *Psychological Review* 81; Herbert Simon, 'How Big is a Chunk?' (1974) 183 *Science* 482; Slava Kalyuga, Paul Chandler and John Sweller, 'When Redundant Text in Multimedia Technical Instruction Can Interfere with Learning' (2004) 46 *Human Factors* 3; Gray, above n 11, 318.
[35] Carlson, Chandler & Sweller, above n 6, 629.

The technique of logic requires that the solver step through a series of propositions before arriving at a conclusion. Each proposition may contain several semantic elements, or chunks. The meaning is left hanging until the exploration is complete, which may involve venturing up several dry gullies. If a dry gully is explored, it is necessary to retain enough historical information to enable back-tracking to the last branching point. It is not difficult to see that the bounds of working memory, both in terms of capacity and duration, will be exceeded by some quite simple problems. The 'give-up' point may be reached before completion of even a single full pass of the conditions. If the problem-solver responds intuitively at this point, the answer can only be a pure guess.

Again, the author would argue that this phenomenon can be observed in post mortem quizzing of students[36] – they frequently postulate scenarios that are not suggested by any of the words in the provision, or are directly inconsistent with later propositions. Generally, when trainees are questioned about the steps of their reasoning, they appear much more conversant with earlier propositions in the chain than later ones, which would not be expected if the earlier ones were flushed out and the later ones rehearsed more recently.[37]

There are also features inherent in natural language that become problematic when the language is used to express logic and law. Pronouns, for example, are constructs that require meaning to be allocated from elsewhere in the text. Until that occurs, working memory must hold the associated data pending completion of the message.

In the following two passages,[38] the word *'that'* is used as a *relative pronoun* introducing a series of relative clauses:

> We cheered the football squad that played the team that brought the mascot that chased the girls that were in the park.
>
> The girls that the mascot that the team that the football squad that we cheered played brought chased were in the park.

In the first passage, the pronoun *'that'* always refers back to the object of the prior clause, so the meaning of each clause is immediately resolved (called *'semantic closure'*).[39]

In the second passage, the pronoun refers back to the subject of the previous clause, so the meaning of all clauses is left hanging until all pronouns are allocated. Failure to close the meaning of a clause makes it impossible to incrementally construct the scene

[36] Self-explanation is an approach used by psychologists. See M. T. H. Chi, '*Self-Explaining Expository Texts: The Dual Processes of Generating Inferences and Repairing Mental Models'* in R Glaser (ed), *Advances in Instructional Psychology* (Mahwah: L. Erlbaum Associates 2000), 161.
[37] The same pattern is evident in written answers given under examination conditions. Reasoning may peter out in several answers on the same paper, indicating that end-of-exam time pressure was not the explanation. Alternatively, an answer that begins with a chain of reasoning may suddenly switch to a stream of unsupported guesses that go on longer than it would take to complete the reasoning process.
[38] From George Miller and Stephen Isard, 'Some Perceptual Consequences of Linguistic Rules' (1963) 2 *Journal of Verbal Learning and Verbal Behaviour* 217.
[39] Frederick Bowers, *Linguistic Aspects of Legislative Expression* (Vancouver: University of British Columbia Press, 1989), 339.

in one's mind. To construct the scene, one needs to know the verbal relationship between the subject and object.

Grammatical rules are learned tacitly well before we learn to read.[40] Allocation of semantic value to a pronoun is a natural process aided by the in-built language mechanism. It becomes harder if, as commonly occurs in law, noun phrases with little natural meaning are used as place-holders (or pseudo-pronouns) for larger expressions. Compare these two passages:

Example 1

A relevant contract is a contract under which a person (the **designated person**), in the course of a business carried on by the **designated person** –

(a) supplies to another person services in relation to the performance of work;

(b) has supplied to the **designated person** the services of persons in relation to the performance of work; or

(c) gives goods to individuals for work to be performed by those individuals in respect of the goods and for the goods to be re-supplied. [41]

Example 2

A relevant contract is a contract under which a person, in the course of a business carried on by him –

(a) supplies to another person services in relation to the performance of work; or

(b) has supplied to him the services of persons in relation to the performance of work; or

(c) gives out goods to natural persons for work to be performed by those persons in respect of those goods and for re-supply of the goods to him. [42]

The author (and fellow staff) find the second version easier to understand because of the use of the pronoun *'him'* rather than the meaningless place-holder, *'designated person'*. The first passage is the current version of a provision from the *Pay-roll Tax Act* 1971 *(Qld)*, more or less copied from corresponding NSW and Victorian legislation. The second passage is based on the obsolete version, abandoned (presumably) to avoid gender-specific language.

The first passage also demonstrates the problem of cognitive load in structured prose. Before any main verb is reached,[43] the reader has already accumulated enough pending data to exceed their cognitive capacity. The branching construct actually inhibits comprehension by postponing the closure of meaning. In Appendix 1, I have rewritten the same provision to address these issues. By allowing some repetition, it ensures that the meaning of each clause is closed before the next one starts. In the author's submission, plain English techniques that encourage structured decomposition of text without addressing cognitive load and semantic closure are often detrimental to comprehension.

[40] Gray, above n 11, 429.
[41] *Pay-roll Tax Act 1971* (Qld.) s 13B(1).
[42] This is close to the original form of the same section enacted in NSW and Victoria.
[43] 'supplies', 'has supplied' and 'gives'.

7. Conclusions on Natural Language

Comparison of natural language with the symbolic languages of mathematical logic highlights its pros and cons as a vehicle for expressing logic. On the one hand, natural language is imprecise, ambiguous and prone to redundancy. It also triggers a reading reflex which is not conducive to understanding. On the other, it is flexible and capable of subtle shades of meaning. The mathematical languages depend on natural language to give their symbols meaning.

When used to express law, natural language has the social and political virtue that ordinary people can read it, however poorly. Even if a language were designed that could deliver the subtlety of natural language with the precision of math, it is doubtful that it would ever be politically palatable to publish law in a form that *manifestly* required an expert to read it.[44] This is in stark contrast to other disciplines. No one would expect an ordinary person to be able to read a medical text and understand it, let alone be able to perform even the most basic surgery.[45] Yet the public fully expects that they *should* be able to understand and interpret law more or less instantly, simply by reading it.

8. The Plain English Movement

Complaints about the inscrutability of legal expression are not new, nor limited to the common law or English language jurisdictions.[46] In the 1970's, a movement developed in America promoting plain English as a solution.[47] It gained momentum in Australia, when, for example, NRMA commissioned a plain English car insurance policy and The NSW Real Estate Institute produced a 'plain' form residential tenancy agreement. In the 1980's, the Commonwealth Government announced a policy for using plain English in its official documents, and the Law Reform Commission of Victoria began a review of the language in legislation.[48] Other English and non-English speaking countries have pursued similar initiatives.[49]

The initial focus of the movement was the structure of the language and the types of words chosen.[50] Outcomes tended to be judged intuitively – there was no reference to relevant cognitive studies of reading and reasoning mechanisms, although such studies already existed. Sometimes, the intuition was very good. The following recommendation of an American expert astutely fleshes out one aspect of lack of closure:

> A major weakness of legal writing in general and of legislation and rules in particular is to put qualifying language between the actor and the action or the action and the object or complement. This weakness separates the working words of the sentence, making it difficult

[44] Lisbeth Campbell, 'Drafting Styles: Fuzzy or Fussy?' (1996) 3 *eLaw Journal: Murdoch University Electronic Journal of Law* 2, par.13.
[45] B J Brown, *Shibboleths of Law: Reification, Plain-English and Popular Legal Symbolism* (Auckland: Legal Research Foundation, 1987), 24.
[46] Dickerson, above n 8; Richard Wydick, *Plain English for Lawyers* (4th ed, Durham: Carolina Academic Press, 1998), 3-4.
[47] Australian Language and Literacy Council, above n 1.
[48] Australian Language and Literacy Council, above n 1, 13-14.
[49] Australian Language and Literacy Council, above n 1, 18-20; Kimble, above n 2.
[50] Penman, above n 1, 3-4.

> for the reader to see the relationship between the actor, the action and the object or complement.[51]

However, the same source refers to the number of letters in a word as a measure of its comprehensibility,[52] highlighting the preoccupation of plain English theory with visual/physical elements such as letters and words rather than the semantic chunks that actually influence comprehension. The same perspective is seen in one explanation given by plain English theorists for preferring the active over the passive voice[53] – i.e. the active voice requires fewer words.[54]

Experts have even devised quality assurance audits of language that applied mathematical formulae to variables such as the number of syllables, words and sentences as a measure of readability.[55] Such techniques ignore the actual meaning or effect of the text on the reader, and consequently have been discredited by the Australian Language and Literacy Council in its 1996 Report,[56] the Commonwealth Office of Parliamentary Counsel (OPC), the latter an active exponent of comprehensible legislation, and other experts.[57] OPC has preferred testing techniques involving model users, including a 'think-aloud' protocol not unlike the 'self-explanation' approach referred to earlier.[58]

Plain English guidelines were later extended to visual features such as the use of white space, headings, font sizes, colour, weight and style.[59] Communication experts complained that preoccupation with the form of words ignored the user context. Penman and Sless, no apologists for traditional plain English theories, espoused a holistic, user-centred approach with *'equal emphasis on verbal and visual comprehensibility'*.[60] They criticised the alleged successes of plain English as unsubstantiated.[61] Brown and Solomon emphasised social and contextual factors,[62] observing that: 'To varying degrees, there is recognition that plain English of itself cannot solve all the problems.'[63]

The difficulties with plain English theory for solving problems of comprehensibility of legislation are not limited to the failure to address the context of the communication. Emphasis on the form of the words and their visual presentation treats the problem primarily as a reading exercise, or on the broader view, as a communication only. This may have some merit when applying plain language to

[51] Martineau, above n 8, 95.
[52] Martineau, above n 8, 77-78.
[53] Wydick, above n 46, 29-30.
[54] Linguists have argued that maintenance of theme is more important than use of active voice: Bowers, above n 39, 282.
[55] See, for example: Grant Richardson and David Smith, 'The Readability of Australia's Goods and Services Tax Legislation: An Empirical Investigation' (2002) 30 *Federal Law Review* 475.
[56] Australian Language and Literacy Council, above n 1, 45, 47.
[57] Penman, above n 1, 3-4.
[58] Chi, above n 37; Australian Literacy and Literary Council, above n 1, 46.
[59] K Brown and N Solomon, 'Plain English – Best Practice in the Public Sector' (1995). Report to the Australian Language and Literacy Council, above n 1, 91.
[60] Penman, Sless and Wiseman (1995) *Best Practice in Accessible Documents in the Private Sector*. Report to the Australian Language and Literacy Council, above n 1, 2.
[61] Penman, above n 1, 3-4.
[62] Brown and Solomon, above n 59, 7-8.
[63] Brown and Solomon, above n 59, 3.

consumer contracts that primarily communicate static information,[64] but when language is used as a specification of a rule to be applied by the reader, at least four cognitive processes are demanded, of which reading is probably the least difficult:

1. Reading the textual terms to understand what they say;
2. Translating the communication into a logic structure;[65]
3. Analysing the facts to ascertain whether they fit the terms;
4. Applying the logic specified in the text to those facts.

A side-effect of over-emphasis on the reading process is that more practical alternatives to 'readable' legislation may be ignored. The goal of writing legislation usable by average citizens without training is often accepted routinely as a social or political imperative.[66] Cognitive studies strongly suggest that this goal is largely unattainable. It requires skills that untrained and unpracticed readers do not have. If this basic reality were recognised, more resources might be directed to achievable outcomes, such as the reported Japanese approach of publishing detailed, narrative accounts of the legislation that affects most citizens.[67]

9. Graphical Methods

The reflex nature of reading and the unsuitability of that reflex for interpreting logic and law suggest that comprehension might be improved by representing the logic of law in a non-linguistic format. However, the mathematical alternatives depend for their meaning on natural language embedded within them.

Much research has been undertaken, especially in the context of science and mathematics teaching, to explore the effects of symbolic, diagrammatic, pictorial and other visual representations in instructional material.[68] This research provides insights into whether such tools will assist in expressing the law.

The simplest forms are visual organisers – either structured text or adjunct aids like boldface headings and summaries. Research on structured text has provided little empirical evidence, but adjunct aids consistently show benefits in conveying relationships between concepts[69] and they are widely used in the design of textbooks.[70]

[64] Though even these documents also contain logical formulae prescribing rights and liabilities governed by conditions.
[65] The reason for separating the first two steps is explained later. It is based on examination of exercises in which trainees are asked to perform only steps 1 and 2, which show that step 2 is a significant hurdle.
[66] Kimble, above n 2, 59; Martineau, above n 8, 8-9; David St L Kelly, '*Plain English in Legislation: The Movement Gathers Pace'* in David St L Kelly (ed.), *Essays on Legislative Drafting* (Adelaide: Adelaide Law Review Association, University of Adelaide,1988), 57.
[67] Brown, above n 45, 24.
[68] Janice Glasgow, N Hari Narayanan and B Chandresekaran, above, n 7.
[69] Martin Eppler, 'A Comparison Between Concept Maps, Mind Maps, Conceptual Diagrams, and Visual Metaphors as Complementary Tools for Knowledge Construction and Sharing' (2006) 5 *Information Visualization* 202. John Clarke, 'Using Visual Organizers to Focus on Thinking' (1991) 34 *Journal of Reading* 526.
[70] Daniel Robinson and Kenneth Kiewra, 'Visual Argument: Graphic Organizers Are Superior to Outlines in Improving Learning From Text' (1995) 87 *Journal of Educational Psychology* 445, 455.

Adjunct aids may take different forms such as outlines, matrices, tree diagrams or tables. Kang[71] summarises the benefits of visual organisers at the conceptual level:-

- They allow users to develop a holistic understanding that words cannot convey;
- They provide users with tools to make thought and organisation processes visible;
- They clarify complex concepts into a simple meaningful display;
- They assist users in processing and restructuring ideas and information;
- They promote recall and retention of learning through synthesis and analysis.

Such results are tempered by the fact that adjunct aids rarely contain equivalent informational content to text-based alternatives. While a conceptual overview is undoubtedly important in law, it is not the major hurdle in problem-solving. To be useful, the logic must be more or less complete. Furthermore, when adjuncts are employed in addition to text, the results are less encouraging.

In one series of experiments[72], participants were presented with 6,500 words of text on abnormal psychology. Some participants received the text with adjunct aids interwoven, others received text alone. In the first experiment, the participants with adjunct aids embedded in their materials proved *worse* in recall of facts represented only in the text, but after a couple of days showed some superiority in understanding relations between concepts. In a follow-up experiment, participants were allowed a 15-minute revision period just before testing a day later. On this occasion, the performance of participants with adjunct aids was superior in a number of areas, especially the participants with graphic organisers (matrices and a tree diagram) rather than a simple outline. Although the second experiment was designed to alleviate perceived time pressures in the first procedure, the results could be interpreted as showing no more than the fact that visual representation is a more effective revision tool than a chapter of blank text when participants are restricted to a 15-minute revision period. A subsequent study supported the theory that graphic organizers only had benefits for delayed revision, but again the bias of an unrealistically short revision period (this time, only 10 minutes) in favour of summary formats seems to undermine even that conclusion.[73]

Visual methods have often been shown to have a negative impact on comprehension because of their tendency to split attention.[74] In fact, introduction of overlapping information in a different modality,[75] whether verbal,[76] spatial,[77] dimensional[78] or

[71] Shumin Kang, 'Using Visual Organizers to Enhance EFL Instruction' (2004) 58 *ELT Journal* 58, 60.
[72] Robinson and Kiewra, above n 70.
[73] Daniel Robinson et al, 'Interactive Effects of Graphic Organizers and Delayed Review on Concept Application' (1998) 67 *Journal of Experimental Education* 1.
[74] Sweller et al (1990), above n 27.
[75] Richard Mayer, Julie Heiser and Steve Lonn, 'Cognitive Constraints on Multimedia Learning: When Presenting More Material Results in Less Understanding' (2001) 93 *Journal of Educational Psychology* 187.

graphical,[79] consistently causes cognitive problems, not only in terms of the load of the extra information, but also the need for the student to mentally integrate the multiple sources.[80]

The issue is related to the idea that students will learn more if they find the subject-matter interesting and that the introduction of interesting text (i.e. 'seductive details'[81]) or graphical adjuncts will improve learning by increasing stimulation. This may be so if the subject-matter itself is interesting and the adjunct is not superfluous, but if the adjunct is added simply to spice up the presentation, it is probably hindering learning. In one series of experiments, first on-screen text and then interesting but inessential video clips were added to a multi-media presentation on the formation of lightning. The effect of the video was to hinder learning, including 'deep' learning and problem-solving ability,[82] compared to participants who only read the text.

Very subtle superfluity of this kind may nullify any beneficial effects. In another study, three groups of participants were trained on the workings of the heart, using three different representations.[83] All participants had the same text, but two of the groups had supplementary diagrams – one a relatively detailed diagram of the heart with some pretensions to pictorial accuracy; the other a more simple diagram, containing only the functional elements essential to the learning task. Results were obtained across a number of cognitive measures, but the general finding was that the simplified diagrams were the most effective in enhancing understanding of the text material. On some measures, the detailed diagrams proved no better than unsupported text.

Advantages have also been found for simplified diagrams over pictorial representations in the solution of mathematical problems,[84] but purely abstract schematics sometimes only assist experts while confusing novices.[85] In a context closer to law, Nelson and Hannan exposed the problem of using even essential diagrams *in conjunction with* text to facilitate logical reasoning. They presented subjects with conditional reasoning tests in 3 forms:- text-only, text with inessential diagrams, and text with diagrams used as essential concrete referents. The best-performed subjects were those using only text.[86]

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[76]Eric Jamet and Olivia Le Bohec, 'The Effect of Redundant Text in Multimedia Instruction' (2007) 32 *Contemporary Educational Psychology* 588.
[77] David Landy and Robert Goldstone, 'How Abstract is Symbolic Thought?' (2007) 33 *Journal of Experimental Psychology: Learning, Memory and Cognition* 720.
[78] P L Gardner, 'Effect of Presentation Sequence, Irrelevant Dimensions, and Instructional Conditions Upon the Attainment of a Meaningful Restricted Conjunctive Concept' (1972) 92 *Journal of Experimental Psychology* 27.
[79] Carlson, Chandler & Sweller, above n 6.
[80] Sweller et al (1990), above n 27; Kalyuga, Chandler and Sweller, above n 35.
[81] Mayer, Heiser and Lonn, above n 75, 189.
[82] Mayer, Heiser and Lonn, above n 75, 196.
[83] Butcher, above n 6.
[84] Mary Hegarty and Maria Kozhevnikov, 'Types of Visual-Spatial Representations and Mathematical Problem-Solving' (1999) 91 *Journal of Educational Psychology* 684.
[85] Marian Petre and T R G Green, 'Learning to Read Graphics: Some Evidence that "Seeing" an Information Display is an Acquired Skill' (1993) 4 *Journal of Visual Languages and Computing* 55; Butcher, above n 6, 185.
[86] R D Nelson and A J Hannan, 'The Use of Drawings as Concrete Referents in Conditional Reasoning Problems' (2002) 16(2) *Applied Cognitive Psychology* 57. Nelson and Hannan argue that their results

Researchers in artificial intelligence, attempting to replicate human reasoning, have often observed that pictures can have falsifying effects, because of their inability to represent certain types of generality.[87] For example, the proposition, 'There is tea in the cup', cannot be pictured without redundantly (and falsely) specifying the shape of the cup and the amount of tea. So while a picture may paint a thousand words, many of those words may be wrong. This phenomenon, in the author's view, goes to the heart of the problem with mental modelling when it is applied to verbal logic. While such modelling need not be visual or imagistic, it nevertheless involves fleshing out the minimal conditions described by a rule into a more complete scenario, and treating that scenario as a template or test-bed for others.

One must be wary of translating findings on scientific and mathematical learning to a legal context, but these studies do suggest it is a considerable challenge to successfully introduce different media and modalities of communication into the representation of law. Logical rules are of their very nature non-pictorial, so any adjunct beyond a table or a concept map may well be extraneous and therefore detrimental.

One further possibility is that conceptual diagrams can be used to encourage an appropriate mode of thought. This is a process known as *priming*. In two experiments, participants were trained in the use and design of knowledge maps, a graphical form that encourages top-down analysis. They then studied purely text-based material on the use of cocaine and the sympathetic nervous system, which did not employ the knowledge mapping techniques. The map-primed participants recalled more macro- and micro-level ideas from the text than those trained solely on text.[88]

10. Possible Solutions to Cognitive Issues

The author heads a team providing legislative training to employees in a government department[89] responsible for administering technical tax legislation.[90] The trainees usually are not legally trained, and with the predominance of self assessment (i.e. by the taxpayer or his professional advisor) for standard scenarios, revenue officers' work involves a disproportionate number of problem cases. Knowledge of State taxation is less commonplace than federal taxation, so prior domain knowledge is often meagre, even for recruits with a strong tax background. New recruits must be skilled quickly to enable them to make a positive contribution to workflows.

A number of more or less novel approaches have been developed to address these challenges. The methods described below are aimed at countering the cognitive and linguistic issues outlined earlier in this article.

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support a 'pragmatic rule-based' cognitive process, rather than mental modelling (p.168); but as they also observe, the diagrams in their procedure introduced the burden of integrating the visual and textual information, with no offsetting informational advantage over pure text.

[87] See generally Janice Glasgow, N Hari Narayanan and B Chandresekaran, above n 7.

[88] Todd Chmielewski and Donald Dansereau, 'Enhancing the Recall of Text: Knowledge Mapping Training Promotes Implicit Transfer' (1998) 90 *Journal of Educational Psychology* 407.

[89] Office of State Revenue, Queensland, an office of Queensland Treasury.

[90] *Pay-roll Tax Act 1971* (Qld.); *Duties Act 2001* (Qld.); *Land Tax Act 1915* (Qld.); *Taxation Administration Act 2001* (Qld.); *Community Ambulance Cover Act 2003* (Qld.); *First Home Owner Grant Act 2000* (Qld.); *Fuel Subsidy Act* 1997 (Qld.).

11. Chunking and Tight Closure in Text-based Materials

We have given considerable attention to the method of expressing text-based materials to assist trainees in 'chunking' concepts and to overcome problems of 'closure' in statements of legal logic. A system of training notes has proven popular in face-to-face training and as an ongoing problem-solving tool. While the notes superficially resemble many bullet-point formats, they employ a number of features specifically directed to cognitive issues:-

- A hierarchical system of bulleting reflects a top-down decomposition of logical concepts and the propositions that underlie them.

- The structural break-down is enforced by both semantic grouping (keeping semantically dependent words together) and graphical means such as indenting and standardised bullet-styles.

- Italics are used, not so much as a method of highlighting, but as an aid to chunking. Italics group words that represent single semantic chunks so that changes in font style separate discrete semantic groups. Italics are sprinkled more generously than a highlighting approach would suggest.

- Each branch of the logical structure tends to contain a complete sub-clause, so that closure of meaning is not suspended over several sub-paragraphs.

    - Ideally, each sub-clause will be a complete sentence in itself. If there are words common to each sub-paragraph, they will either be repeated for each sub-clause or limited to a very small chunk easily retained and carried forward in working memory.

    - A sub-clause will be a decomposition or expansion of the higher level clause, so that it appears as a natural follow-on from the higher clause – a technique we call semantic linkage.[91]

    - When terms are used to represent larger concepts, the terms are given meaningful labels rather than arbitrary ones that leave the actual meaning pending till later clarification.

To be effective, it is not sufficient to simply break text up into pieces, as plain English theories sometimes imply. To aid in cognition, the 'pieces' must have either a single semantic value or a closed clausal meaning that can be readily retrieved from long-term memory by semantic associations.

An example of the structured notes is provided in Appendix 2. Trainee feedback on the notes is discussed below.

12. Diagrammatic Modelling

Diagrams present a real challenge to legal educators. Redundancy is likely to split attention and create unnecessary cognitive load in integrating the visual representation

[91] Consistent with the idea of maintaining a theme; above n 52.

with the text-based component. Nevertheless, the adverse effect of the reading reflex encourages us to try graphical methods.

Since law and logic are inherently non-pictorial, we have developed a diagrammatic modelling language for clausal logic that is complete in itself, in that it can express any logical proposition, but simple enough to be comprehensible almost at a glance. It resembles modelling languages used in engineering and software design, such as the Unified Modelling Language (UML), Open Modelling Language (OML) and Entity Relationship (ER) Diagrams, but has extra artifacts specifically designed to accommodate the logical constructs commonplace in law. It is capable of expressing relationships between concepts, sub-classifications and logical decomposition into propositions.

The diagrams are based on propositional concepts, represented by rectangular boxes. Relationships between concepts are depicted by a small diamond connected by lines to the related concepts. Concepts may be decomposed into either sub-categories or propositions (conditions) that must be satisfied to establish the existence of the concept. Arrowed lines represent decompositions, not flow. The plus (+) sign is used to represent 'and' constructs, and the vertical bar (|) has been borrowed from computer languages to represent 'or'. Special notation is also available for list-style definitions.

A sample is given in Appendix 3 and a simple specification for the modelling language appears in Appendix 4. Such diagrams have been in use in all our tax courses since the start of 2008.

Conscious of the potential for split attention and integrative load, the diagrams are used in training separate from the text, for priming, elaboration and revision. Staff routinely employ the diagrams to solve problems during training and report that they continue to use them in practice for real-world problems. Likewise, the training personnel frequently resort to the diagrams to refresh their knowledge of areas they have not recently taught and to compose problem questions that test particular branches of legislative logic. Logic diagrams allow the user to concentrate on the logical structure but deliver enough detail to assist in the solution of significant problems.

13. Practice and Feedback

When graphical logic was first used, trainees were given no specific training on the methodology and were merely told briefly about the general style of the diagrams and the conventional meanings of the 'and' (+) and 'or' (|) symbols. As a priming exercise prior to any actual training on the subject-matter, they were then given quizzes in which they were asked to 'guess' the answers to questions using only the diagrams and their common sense. The questions were designed to require them to explore the logic in the diagrams to arrive at their answers. The answers were then collected anonymously and marked.

In this context, it was not possible to control the level of prior background knowledge of the trainees, nor the depth of their understanding of their answers, but in general they comfortably passed the quizzes with average marks in 3 quizzes of 80%, 88% and 60%. While these results must be viewed with reservations, they do suggest that

the trainees were able to successfully follow logic in diagrammatic form with little explanation.

After further training on text-based materials, trainees were observed solving problems in whatever manner they saw fit. They used both the structured notes and diagrams, as well as the Act itself, often selectively working back and forth from one to the other in a manner that suggested that they derived different benefits from each format.[92]

Following a later course on a major legislative amendment,[93] we sought feedback directed to the use and intended use by the trainees of the notes and diagrams. A snapshot of the relevant results is presented in Appendix 5. It shows a general appreciation for the different formats, different weighting of their utility, and little adverse reaction. There was a broad intention to use both the notes and diagrams in future problem-solving work, although the primary source is always the Act itself. However, we generally feel that the goal of these different formats is to provide *unconscious* enhancement to learning, about which trainees cannot consciously report. If priming were successful, for example, trainees would not be aware of it.

We regularly receive unsolicited feedback and comment to the effect that both the notes and diagrams are used to advantage in practice and are regarded as helpful tools long after the formal training is complete. We have even received positive feedback about the italicization in the notes. If we were to judge the greatest success of these methods, it would not be in face-to-face training, but in the months following when former trainees continue to employ them to improve their skills and the quality of their decisions.

14. Training Approach

In more recent times, we have developed a course on statutory interpretation that contains no law, focusing instead on the logical basis of reasoning and the cognitive and linguistic factors that create the real difficulties in interpreting legislation. Studies have shown that training on reasoning can significantly improve performance on reasoning tests,[94] so the course encourages top-down decomposition of legislative logic rather than linear reading, and teaches the graphic and symbolic methods in more detail. The jury is still out on whether this approach will be successful, but the goal is to encourage staff to better understand the problems they face in interpreting relatively complex tax legislation and to develop appropriate problem-solving schemas. By teaching the graphical language as a standard, we hope to promote fluency in 'reading' the diagrams.

This course has highlighted the need for a rapid tool for sketching the logic of legislation. Diagrams are relatively easy to read, but quite time-consuming to design and draw from scratch, particularly with no intermediate representation of the logic to

[92] This led us in future courses to separate the notes and the diagrams into separate booklets, to make it easier to cross-reference the two sources. We have resisted the temptation to provide explicit cross-references in the diagrams, though some trainees have requested it, as it would visually pollute the diagrams with numeric details that make them less easy to follow.
[93] The substantial nature of the amendment meant that the trainees could not rely on background knowledge only. It also meant that more senior staff than usual were in attendance.
[94] Nelson and Hannan, above n 86.

work from. Writing structured notes is likewise a substantial task, not suitable for a class exercise.

For these reasons, we have adapted from linguistics the technique of context-free grammars to decompose the logical structure of a provision. These grammars were introduced by the linguist Noam Chomsky[95] to specify the structure of natural languages, and they are now used in systems programming to design computer programming languages. They are particularly well-suited to rapid top-down analysis.

Appendix 6 is a grammar of the provision contained in Example 1. Each 'sentence' of the grammar is called a production, which decomposes the left-hand side into the elements on the right. Terms in triangular brackets (called non-terminals) appearing on the right-hand side are decomposed in later productions where they appear on the left. Unbracketed terms are called terminals. In legislation they will often be undefined words that bear their ordinary English meaning. We use the standard clausal logic symbols of a comma to mean 'and'; and a semicolon to mean 'or'.[96]

Although grammars are better for decomposing concepts than describing relationships between them, they are sufficiently simple that trainees can use them in logic exercises with very little explanation.[97] The author also uses them as an intermediate representation prior to designing a diagram.

Again, we have anonymously collected and studied grammars prepared by trainees during class exercises that require them to decompose text into its logical structure (without the need to interpret it or apply it to facts). They reveal a reasonable facility among trainees for chunking words into concepts, but not for relating concepts in a top-down, hierarchical fashion. Instead, they adopt a linear structure, mirroring the linear stream of the text. We regard a transition from linear 'reading' to top-down logical analysis as a necessary precondition to developing skill in solving legal problems.[98] Practice with grammars is a possible path towards that goal.

Conclusion

Law is notoriously difficult to read and comprehend in written form. To date, suggested solutions have focused almost exclusively on the structure and form of the words, rather than the logic.

Explanations for the difficulties in comprehending written law can readily be found in existing literature on cognitive and educational psychology, linguistics, mathematics, communications and even artificial intelligence. This literature suggests that solutions must address cognitive factors beyond the battleground of the words themselves.

[95] Noam Chomsky, 'Three Models for the Description of Language' (1956) 2(3) *IRE Transactions on Information Theory* IT, 113-124.

[96] It would be possible to use the words themselves, but the theme of the course is to by-pass the reading reflex in favour a conceptual analysis.

[97] It doesn't follow that trainees produce good logical expansions at their first try. The difficulty trainees have in decomposing the logic of a provision, free of the need to apply that logic, exposes how unsuited simple reading mechanisms are as schemas for understanding the structure of logic.

[98] The tendency towards a linear analysis mirroring the text suggests that the linear structure of text, and of the reading process that interprets it, is one of the ways in which reading interferes with the comprehension of logic described in text. This is consistent with the findings elsewhere that graphical adjuncts have particular advantages over text in conveying non-linear, conceptual structure.

Verbal or visual solutions that fail to address the cognitive issues may actually be counter-productive, reducing comprehension by breaking language up into meaningless, disconnected pieces that translate into random, disjointed thoughts.

Diagrams and other visual adjuncts are recognised as tools for elaborating and elucidating concepts, and their use has been promoted in educational and publishing contexts. Legal professionals have not been averse to such techniques – graphical techniques have even been implemented in legislation – but their applicability to legal subject-matter has not been thoroughly explored. Cross-disciplinary research identifies the dangers in these formats, and points to appropriate methods for applying visual techniques to legal content.

The methods described in this article are presented in the hope of encouraging fellow legal educators to experiment with them to develop a greater understanding of their practical benefits.

Qualifications

The specific problem addressed by this article is the representation of law in a comprehensible form. It assumes that the goal is to apply the law to stated facts. While I have concentrated on statute law because it presents 'cleaner' examples, the principles apply equally to the application of common law (so long as its content is known and formulated).

In real life, the interpretation of 'fuzzy' facts and evidence is just as important as applying law, perhaps even more so for practitioners in the field. We have not addressed the question of analysing facts, but the author would tentatively suggest that a cognitive analysis is also likely to be fruitful in that field.

An assumption underlying this research is that the trainees need to solve legal problems. That is true of law students, legal professionals and government officers required to administer legislation, but may not be true when teaching law to non-practitioners such as students of business degrees. Teaching law for use in a commercial context has quite a different learning goal. At least one university has made significant changes to the way it teaches law to its business students, reducing the focus on legal method in favour of commercial problem solving.[99] We applaud that innovation, but do not address it in this article.

[99] Lillian Corbin, 'Teaching Business Law to Non-Law Students' (2002) 9(1) *eLawJournal: Murdoch Electronic Journal of Law*.

Appendix 1 – Text Reducing Cognitive Load

All of the following are relevant contracts:-

(a) A contract under which someone in the course of their business supplies services to someone else in relation to the performance of work.

(b) A contract under which someone in the course of their business is supplied with services of someone else in relation to the performance of work.

(c) A contract under which someone in the course of their business gives out goods to individuals for the individuals:-

i. to perform work in respect of the goods, and then

ii. to return them.

Appendix 2 – Structured Notes

Supplier provides services as part of a genuine independent business[100]

- A contract is excluded IF:-
    - the services are supplied to a person in the course of the person's business;

    AND

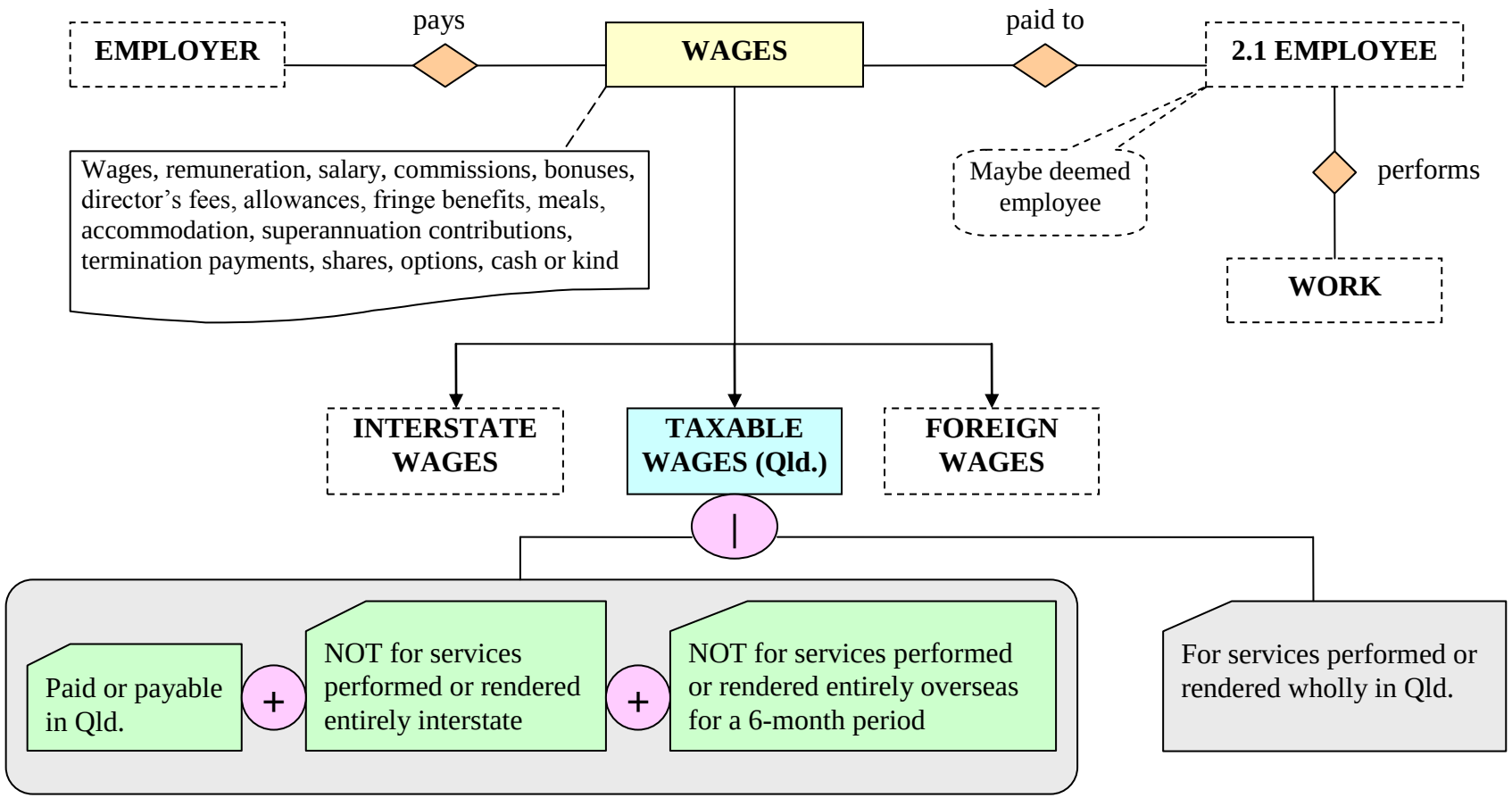
        - the *commissioner* is *satisfied* the contractor *ordinarily* in that financial year performed or rendered services of the *same kind* to the *public generally – s.13B(2)(b)(iv)*, *s.13B(3)*, defn. "relevant financial year";

        OR

        - the *work* is *performed* by *2 or more people* employed by or performing services for the contractor, at least *one of whom* is *not* the *contractor himself* or a *contracting partner – s.13B(2)(c)*.
            - If the *contractor* is a *company*, a *worker* can be a *principal* of the business (director or majority shareholder) and still *qualify* as an *employee worker*.
            - This exclusion *doesn't apply* if the commissioner is *satisfied* there was an *intention* to *avoid tax – s.13B(4).*

[100] References are to the *Pay-roll Tax Act 1971* (Qld.).

Appendix 3 – Logic Diagram



Appendix 4 – Specification – Legal Modelling Language

INTRODUCTION

- This is a *specification* for a *modelling language* to be used for representing legal principles *diagrammatically*.

- It is a *conventional method* for modelling legal principles comprised of *multiple propositions* (conditions) that must be *satisfied* to establish a *legal conclusion*, such as a legal liability, right or status.

- It is not recommended for representing factual scenarios.

- It is *complete* in the sense that any legal proposition can be fully expressed if desired. However, it is intended to be *flexible* and *facilitative*. Just enough is specified to allow you to express the scope of a law without unnecessary strictures.

OBJECTS

- The *primary entities* within a diagram are the *conceptual objects*. They may reflect *real-life objects*, such as items of property, or actors, such as owners of property or persons suffering liabilities, or *imaginary concepts* like rights and licences.

    - They tend to reflect noun concepts rather than verbs or adjectival attributes.

    - *Conceptual objects* are referred to generally as *"objects"*, and are represented by a *rectangular box* with an *internal label*.

Concrete and Abstract Objects

- There are two kinds of objects – *concrete* and *abstract*.

- *Concrete objects* are objects elaborated as entities within the diagram.

    - *Concrete objects* are represented as *rectangles* (or squares) bounded by a *continuous* (unbroken) *line*. They are labelled with text inside the box.

    - eg. In Appendix 3, "Wages" and "Taxable Wages (Qld.)" are concrete objects.

- *Abstract objects* are included in the diagram only because of their relationship with a concrete object. In other words, they are shown to explain the context of a concrete object, not to explain themselves.

    - *Abstract objects* are represented as *rectangles* bounded by a *broken line*. They are labelled internally like concrete objects.

- eg. In Appendix 3, the objects "Employer", "Employee", "Work", "Foreign Wages" and "Interstate Wages" are all abstract objects.

- An *abstract object* in one diagram may be *expanded* as a *concrete object* in *another diagram*. If so, its label in the diagram in which it is abstract should include the number of the other diagram.

- eg. Appendix 3 shows that the object "Employee" is elaborated in Diagram 2.1.

RELATIONSHIPS BETWEEN OBJECTS

- The language can describe the following *relationships* between objects:-

  - *Generalisation* (classification) and *specialisation* (sub-classification)

    - DESCRIPTION: One object (the *generalisation*) is comprised of a number of different sub-types (*specialisations*).

    - REPRESENTATION: The generalisation is shown above the specialisations, and is connected to them by lines with arrows pointing downward to the specialised types. The effect is similar to a family tree which is, in effect, what it represents.

    - eg. In Appendix 3, the generalisation "Wages" is decomposed into three sub-types, two of which are abstract (interstate wages and foreign wages) and one of which (taxable wages) is concrete and therefore expanded in the drawing.

    - If the generalisation is merely an abstraction, the relationship may be represented by a single, block arrow pointing upward to the generalisation.

  - *Interactions*

    - DESCRIPTION: One object interacts with OR produces another.

    - REPRESENTATION: Interacting objects are linked by a line with a diamond in the centre. The diamond is labelled *externally* by *floating text*. If the nature of the interaction is obvious, the diamond and/or its label can be omitted, leaving the objects connected only by a line without arrows.

    - eg. In Appendix 3, an employer pays a wages to an employee. The wages object shares an interaction with each of the employer ("pays") and employee ("paid to"). In a different context, if the wages themselves were not significant, there could be just employer and employee objects linked by a "pays wages" interaction.

PROPOSITIONS

Conceptual objects can also be decomposed into propositions that are the conditions that must be satisfied to establish the concept.

Types of Proposition

- *Conditional propositions* can be divided into two forms:-
  - *Definition*; and/or
  - *Formula*.
- *Definitions* may be *exhaustive* (typically using the word "means") or *inclusive* (typically using the word "includes"), or a combination of both.
- A *formula* is a verbal algorithm by which facts can be demonstrated to fall within a concept.
- Each of these constructs is *propositional* in nature.
  - An *exhaustive definition* says: You fit the meaning *IF AND ONLY IF* you are this OR this OR … etc.
  - An *inclusive definition* says: You fit the meaning *IF* you are this OR this OR … etc.
  - A *formula* says: You fit the meaning *IF* these conditions are satisfied.
- In other words, *definitions are formulas* in which the conditions are typically flat (unnested) lists of single-phrased (normally single-word) labels connected disjunctively (by OR).
- Since definitions are commonplace in law, a special syntax is provided for them.
- *Definitions* can be displayed in a *single box* with a *curved bottom edge*, in the style of a document or report symbol in standard Flowchart language. The list is placed inside the box, separated by commas. The box is connected to its object or relationship by an arrowed line pointing to the definition.
  - If it is merely inclusive, the text should start with the word INCLUDES, otherwise, it is assumed to be exhaustive.
  - Each item in the list is treated disjunctively, unless the text shows otherwise.
  - Appendix 3 contains an example of a definition of "Wages".
- *Formulas* are displayed as *propositions* connected by 'AND's or 'OR's (*connectives*).

- *Propositions* are represented in *boxes* with the *top left corner cut*, like the *punch-card symbol* in standard Flowchart language. The boxes may be grouped horizontally or vertically.
    - Each propositional box is linked to its object by an un-arrowed, probably branching, line.
    - Each propositional box must share a connective with other propositions in its group.
    - A group of inter-connected propositions may be grouped not only by a branching line but, for easier readability, by a surrounding oblong (round-cornered rectangle). In this case, the branching line need only connect to the group box, not to each individual proposition.
- In Appendix 3, the "Taxable Wages (Qld.)" object is decomposed into several branching propositions.
- *Connectives* (operators) are represented by a circle with the relevant operator inside – the *plus sign* (+) for AND, the *vertical line* (|) for OR. They can also have an external label, such as "NOT" to qualify them.
- Where a *group of propositions* is connected by the *same connective*, the connective can be displayed once at the branching point, in which case it need not be repeated between each proposition. E.g. In Appendix 3, the disjuncts under "Taxable Wages".
- Alternatively, propositions may be linked by the connective only, without any lines. E.g. In Appendix 3, the left-hand conjunctive grouping under "Taxable Wages".
- Other operators can be specified. The < and > signs can be used to represent "greater of" or "lesser of" two propositions that evaluate to a numerical amount or a time/date expression. This is really a specialised version of the "OR" operator, where the choice between the alternatives is based on an evaluation, and the alternatives are mutually exclusive.
- Other operators can be customized by appending a label to an empty circle.

GROUPING

- Any objects or propositions can be grouped within a (round-cornered) oblong. This is a visual aid that is not necessary to the logical integrity of the diagram, but is often essential to make a diagram easily "readable". It can also allow a single operator to be appended to the group.
    - Visual grouping may be enhanced by colouring the grouped objects the same colour and/or by colouring the grouping oblong itself.
    - In Appendix 3, the three left-hand propositions (coloured green) are grouped by an oblong (coloured grey).

NOTES

- For flexibility, a number of methods are available to append a comment to an object. Comments should not be used as a substitute for objects or relationships that can be readily included in the diagram.

- *Notes* about an *object* or *relationship* may be appended either by:-

  - a *call-out box* (as in Appendix 3, pointing to the "Employee" object);

  - a *box with a slanted top edge*, in the style of a *"manual keying" symbol* in standard Flowchart language. The box is linked to its target by an *un-arrowed dotted line*; OR

  - *floating text* linked to the object by an un-arrowed *dotted line*.

- If a box is used to enclose a *comment*, the *border* should always be *dashed*.

Appendix 5 – Feedback on Logic Diagrams and Structured Notes

FEEDBACK										
No.	**Question**	**Yes**	**No**	**Abstain**	**Never**	**Seldom**	**Occasionally**	**Often**	**Always**	**Percentage**
1	Did you find that you could usefully employ the diagrams to attempt the guessing games? ("Yes" or "No")	15	1	1						93.8%
2	Do you think that more instruction on the diagramming method would have improved your ability to use the diagrams to solve problems? ("Yes" or "No")	9	6	2						60.0%
3	Did you use the diagrams in later problem-solving and quizzes during the course? ("Yes" or "No")	17	0	0						100.0%
4	Did you find that the diagrams improved your ability to read and understand provisions in the Act? ("Yes" or "No")	15	2	0						88.2%
5	Did you use the Notes for problem-solving during the course? ("Yes" or "No).	15	1	1						93.8%
6	Have you found that the Notes make it easier to read and understand the Act? ("Yes" or "No")	14	3	0						82.4%
7	When solving problems in the future, which resource are you likely to use? (Tick the appropriate response)									**Occasionally +**
	Notes				1	1	5.5	8.5	2	88.9%
	Diagrams				1	1	9.5	5.5	0	88.9%
	Act				0	0	2	5	10	100.0%
	Memory				0	4	4	4	4	75.0%
	Other (web, practice, directions, revenue rulings)*				0	0	1	1	0	
	Other (unspecified - could be web, practice directions, revenue rulings)				0	0	1	2	0	

Appendix 6 – Grammar for Relevant Contract Provisions

<relevant_contract>	→	<supply_services> ; <receive_services> ; <services_on_goods>
<supply_services>	→	contract, <services>, supplier, in_course_of_business
<receive_services>	→	contract, <services>, recipient, in_course_of_business
<services_on_goods>	→	contract, goods, <giver>, in_course_of_business, <worker>, work_on_goods, <re-supply>
<services>	→	<worker>, work
<giver>	→	<person>, goods, delivery
<worker>	→	individual, work
<person>	→	individual ; company
<re-supply>	→	goods, <giver>, <worker>, return_of_goods