The Quest for Coherence

Review of *Inferences During Reading*
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First, a little about the reviewer, and some background …
When I was invited to review this book, a glance through the contents and list of contributors both intimidated and excited me. I recognized the names of some giants in the field, and reflected on my capacity to evaluate their work. I pressed ahead in the knowledge that I would learn something, and perhaps bring the perspective of one who uses their research.

My background is in educational psychology rather than cognitive psychology or neuroscience, which will explain the understandings I bring (or lack thereof) and stance I have taken in this review. My career reflects to some degree the huge debt that the teaching profession owes to cognitive psychologists and neuroscientists such as those who have contributed to this book. I originally trained as an elementary teacher, retrained in special education, and taught students with severe disabilities for almost a decade while completing doctoral studies. After moving to the university sector to teach special education units in mainstream teacher education programs, it quickly became clear that it was the *reading difficulties* of many students that were of greatest concern to teachers. So began my first serious foray into the research on reading development and how to teach it most effectively. I looked first at studies being conducted by education researchers, and quickly realised that while I had been 'protected' in special education settings, strange forces had taken hold of the mainstream education field. "Whole language"(Goodman & Goodman, 1979, Smith, 1973, 1975), a new ideological approach to teaching reading, had gained ascendancy.

This approach posits that "learning to read is accomplished naturally and holistically through immersion in print-rich and language-rich environments" (as explained by Reutzell & Cooter (2005, Top-down Theories of the Reading Process section, dot point 3). Teachers were advised – indeed exhorted – to read and reread 'authentic' stories to children, the theory being that the children would internalize the language structures and spellings of words as they were inducted into the world of reading. Reading, as a language-based skill, would develop without direct teaching, just as learning oral language develops without direct teaching. Instruction in letter-sound relationships (or language structures or grammar) was deemed an unnecessary burden on teachers and children. This model had great intuitive appeal for teachers and many teacher educators, who rejected research findings that emerged from anything but 'authentic' classrooms. The whole language approach thus became the dominant model in university teacher education programs in the 1980s and 1990s.

Adherence to this model persisted – and continues to persist in some quarters - despite a growing body of evidence that undermined the principles on which it

was based. Functional magnetic resonance imaging research reveals that additional parts of the brain are active during reading, not just those that are active when speaking (Shaywitz, 2003; Shaywitz & Shaywitz, 2004; Sousa, 2005). Learning to read is not the same as learning to speak. And while some children with rich language backgrounds do learn to read in a seemingly effortless way, most need at least some level of explicit instruction, and some need a great deal of intensive instruction. Large-scale reviews of effective reading programs (Adams, 1990; NICHHD, 2000; Rose, 2006) have consistently supported the explicit teaching of the component parts of reading. In Adams' (1990) words, "deep and thorough knowledge of letters, spelling patterns and words… are of inescapable importance to both skillful reading and its acquisition." (p. 416).

Nevertheless for nearly three decades, even students who did learn to read were not taught the structures that underpin our language. *Many of those students are now our teachers*: they missed this crucial information while at elementary school themselves, and did not have the opportunity to develop these understandings while undergoing teacher training during those 'lost' decades. Thus a significant proportion of practicing teachers do not have the knowledge or skills to teach reading most effectively, especially to children who arrive at school without the oral language facility that forms the foundation of reading.

This is why we have needed to rely on the work of researchers such as those who contributed to this book. They have provided the evidence base we use to develop teachers' knowledge of the reading process and how to teach it most effectively. As the Director of a small research center that focuses on reading difficulties, I now spend my time *translating* reading research outcomes into recommendations for educational policy and the instructional practice of teachers. My research involves supporting, monitoring and evaluating the implementation of evidence-based reading instruction, mostly in schools serving communities of low socio-economic index, including extremely remote Aboriginal schools. These contexts are a long way from the controlled environments in which many of the studies reported here took place, but I have seen the impact that an evidence-based approach to teaching reading can have (Konza, 2013; 2014; 2015; Konza, Fried, & McKennariey, 2013).

Now to the review…

Some general comments…
This text has enormous strengths, particularly for the research community, and to my mind, a couple of weaknesses. It presents a comprehensive account of what is known about inferences in reading: the processes involved; factors that facilitate and inhibit inferences; their use in narrative and expository text; and in multimedia and online materials. Efforts to locate the source of inferences within the anatomy of brain are explored, and further avenues of research are suggested.

Chapters are logically presented – all hail to the editors for the largely consistent format where, after a brief introduction, the organization of the chapter is explained, the reader is told how the chapter will unfold, it unfolds as promised, and the major findings summarized. Nevertheless, I found myself reading the conclusions of some of the chapters where the subject matter was more distant from my area of expertise to 'get the gist', before returning to the challenge of close and careful reading. Abstracts might have been helpful in those cases.

All authors appeared to appreciate the 'free rein' they were afforded. Some chapters provide a brief glimpse into the personal lives and working histories of the researchers who take readers on their journey from one study to another; and explain how work from within and outside their particular fields has informed their own. There is considerable cross–referencing of chapters and ideas. The enthusiasm and fascination – dare I use the word *passion* - that the researchers have for their research is evident, as is the respect they have for the work of their colleagues.

This text reveals the meticulous approach to research that defines the true expert: extensive reviewing of literature; tight control of variables; detailed consideration of methodological issues; careful documentation of the research processes; cautious drawing of conclusions; and always the raising of questions yet to be answered. Without exception, chapters are densely referenced with landmark studies and the extensive literature base that preceded each study, and include research in press at the time of writing and as yet unpublished studies.

As is probably inevitable when multiple authors are involved across different areas of expertise, some chapters are much more accessible than others. Some of the most difficult for those not immersed in the fields of cognitive psychology or neuroscience appear early in the book, and would deter the unwary reader who picked it up in anticipation of some broad insights into the comprehension process. Even a very motivated teacher who could gain from some chapters, is unlikely to persist.

Another disappointment was the number of figures that are difficult to read because of the print size and degree of shading. In some cases (p. 219; p. 239), authors refer to colored sections of a figure which are not apparent in black and white reproduction, and which make interpretation of the figures almost impossible.

These are, however, minor complaints, and far outweighed by the richness of the offerings. I have approached the rest of the review by summarizing sections that I believe are of particular relevance to researchers and practitioners in education, and inserted questions and musings along the way.

What is an inference?
Kendeou defines an inference as **"**information retrieved or generated during reading to *fill in* information that is left implicit in a text" (p.161); and points out that without the efficiency of inferences – of using our background knowledge to supply information required for understanding but not explicitly stated - much writing and reading would be too cumbersome to imagine. Text would be burdened with a level of detail that would tax the strongest memory capacity and mostly obscure rather than enhance meaning.

According to Pratt & Yamasaki, "inferences are one of the hallmarks of skilled comprehension" (p. 210). It is true that inferences in reading can only occur when the basic decoding aspects of reading have been mastered, but in fact very early readers can construct inferences, so there is clearly more to know about them!

Are all inferences the same?
Two broadly accepted types of inferences are referred to throughout the text – *passive*, and *active or strategic* – although a number of contributors expanded on these in some way. *Passive* inferences operate automatically, below the conscious level, and so are rapid and effortless. They occur *online* (a term used within the field to denote 'while reading') when the text immediately activates related concepts held in memory. Singer provides the example: "The patient was examined. The doctor made some notes" (p. 68). Most readers would assume that consecutive sentences are related and understand as part of their *world knowledge* that doctors often make notes when examining patients, and that the notes referred to in the second sentence related to the patient in the first without this being explicitly stated.

At this stage, a level of knowledge referred to as the *textbase* is formed, based on the literal content of the text and the use on occasions of minimal inferences prompted by single words or phrases. (Butcher and Davis [p. 323] include a *surface level* of knowledge that occurs even before the textbase, consisting of individual words and syntax, a refinement included in the early models proposed by Kintsch [1988], and van Dijk and Kintsch [1983]). Because passive inferences are automatic, they may be irrelevant or even misleading: the reader cannot know what associations may or may not be relevant to future understanding at any single point. Nevertheless, passive inferences are required in most texts to maintain overall meaning or coherence.

The second type of inference involves *active or strategic* processes that are not automatic, but consciously employed. They may be used when meaning breaks down in an attempt to regain coherence, but can also be used as an 'optional extra' to elaborate meaning or to predict likely outcomes. Inferences are supported by the reader's knowledge not only of single words, but also of the many potential associated concepts that are activated. Active or strategic inferences operate at a more complex cognitive level than passive inferences, and are more likely in proficient readers who have a greater store of world

knowledge and well-developed executive functions. During this stage of processing, a *situation model* emerges which is continually updated and refined as a result of the ongoing interplay between text reading and inference generation. It constantly evolves to be the most coherent representation of the situation described and evoked by the text at any one time.

What drives inference generation?
It is generally accepted that good readers are motivated to find meaning in their moment-by moment reading, and in the bigger picture that is formed as a result of extended reading, and how well it meshes with what they know about the world. This process necessarily involves activation of existing *world knowledge*, and monitoring what is read to ensure *coherence*. If readers are faced with contradictions or incongruities, meaning is interrupted to some extent.

According to most references to these processes in the text, it is at this point that new or revised inferences are generated in our attempt to regain, or construct coherence. The pervasive assumption is that interruption to meaning has occurred at the discourse level. What seems to be missing, however, is any reference to the obvious first step a proficient reader would take: to check whether a simple text-level error had occurred. Was a word misread? Did an unknown word appear? We might reread a section, check a word meaning, or read ahead a little to see if the difficulty resolves itself. It could be that these steps are assumed, and are included in the recognition that text level reading must be accurate before any inferences can be made. It is an unfortunate reality, however, that some within the field of education would take this omission as support for directing students to reread or to read on as their only strategies when meaning breaks down. Close attention to accurate word reading as the first step in meaningful reading is still required.

Apart from this quibble, the explanation of what drives our quest for coherence seems very sound. Singer's (p. 70) analogy of the reader as a deductive reasoner solving an *enthymeme* (had to look that one up!) is an apt reminder of the sophistication of the processes that support inferences.

What happens when inferences are generated?
The *construction-integration (CI) theory of comprehension* is widely cited in the text, and is consistent with the explanation of how inferences are made. In the first stage, *construction* of meaning begins when text reading activates knowledge in long-term memory and is combined with the contents of working memory. This is followed by the *integration* of current information and the newly activated knowledge in working memory.

Different or adapted models of inferences and inference generation are offered, all of which promote further thinking about these processes. Kendou presents a plausible case for a *general inference skill* that generalizes across contexts and involves both activation and integration of information (pp. 167-171). This is

supported by Butcher and Davies, who contend that the processes contributing to comprehension in on-line learning are essentially the same as those required in traditional text: activation of prior knowledge; sequencing, connecting and integrating new information, and monitoring overall coherence (p. 325).

Perfetti and Stafura's three-tiered model adds an intermediate level of implicit meaning derived directly from the text between literal meaning at the base, and more sophisticated meaning requiring knowledge beyond the text at the apex (p. 15). Singer's validation model (pp. 69-80) incorporates the understanding that coherence can only be established through validation processing because the relevance of some activated knowledge is not apparent at the moment of reading. Among others, the distributed situation space (DSS) model (Noordman, Vonk, Cozijn & Frank, pp. 281-283) is described, and new critiques of the constructionist model of inference (Graesser, Li & Feng, pp. 293-300) are included. The quest for coherence is a common component of each. All contribute to the sense of this book offering a far-reaching view over the landscape of current research in this field, and potential future directions.

I found de Vega's embodied approach (pp.182-188) particularly engaging. It posits that action words and sentences activate motor areas of the brain, and that brain mechanisms used in actual movements are also involved to some extent in linguistic processing. This started an ongoing conversation with a colleague about the implications of embodiment for teaching reading comprehension and the development of a range of reading skills. And that, of course, is precisely why we need leaders in the field extending, modifying and even challenging widely accepted models.

Inferences in narrative text
The chapters that investigate inferences in narrative and expository texts would be of particular interest to educators. Goldman, McCarthy & Burkett analysed inferences in *literary* texts, which, unlike nonliterary texts, contain both a literal meaning, and a deeper meaning (pp. 389-392). The deeper meaning, or *interpretive stance,* demands integration of the literal text – in some cases the whole narrative - with knowledge of text genres and plot structures, and of constructs such as motivation, moral development and philosophical systems. Other intriguing information in this chapter about the differences between the ways novices and experts respond to literary texts, and how "global interpretive inferences" do not develop in novices without "prompting" (teaching) (pp. 392-398) would be of great value to secondary teachers, many of whom struggle to engage adolescents in exercises of this sort.

Inferences in expository text
Lorch provides an excellent case for increased research on inferences in expository text. As he eloquently puts it:

> "With narrative, we are in the world of inferencing in the service
> of understanding; with exposition, we are in the world of
> inferencing in the service of learning." (p. 358)

Expository text is more often the vehicle for learning, yet less is known about how inferences are formed in these texts that differ greatly in structure from the relatively straightforward causal structure of narratives. Readers usually have less knowledge of the subject on which to draw; expository text is much more complex, with single texts potentially including descriptions, procedures, maps, tables, diagrams, to name only a few text types; and the large quantity of new material challenges working memory's ability to integrate with prior knowledge to develop the situation model. In essence, expository text is harder and therefore engagement requires more time on task and motivation. This chapter gave me a new appreciation of the complexity of learning from expository texts. It provides much food for thought for teachers, as well as prompting the need for further research in this critical area of learning.

Inferences using multimedia and online materials

An important inclusion in the text is research around inferences in on-line material. With learning increasingly occurring in these environments, the reading landscape has undergone enormous changes. Reading entire documents of known authorship has been replaced by reading of multiple documents (but rarely in their entirety), often of diverse origins, and increasingly interrupted by advertising. Text is accompanied not only by illustrations, diagrams and graphs, but also by animations, videos, and interactive features. Butcher and Davis, in recognizing the challenges of generating inferences across multiple on-line documents, explored many different aspects of inference generation with on-line and multimedia learning. This is an important contribution to an area that can only become more important and more complex.

Developments in language and discourse technology

Graesser, Li & Feng use advances in technology to broaden another avenue of research. Using computational linguistics, they developed the *Coh-Matrix* to scale real texts on hundreds of dimensions related to the generation of inferences (p. 301). Their findings regarding text elements that promote inferences, such as a high percentage of word overlap across sentences, the use of causal and temporal connectives, and the use of concrete rather than abstract words, provide useful guidelines for writers as well as directions for teachers when selecting texts to teach this process. Their use of real texts is also an important development in a field where so much research is based on short texts created to control for particular variables, but which are far from the texts that are typically read.

Factors affecting inference generation

This book is permeated with discussion of different factors that influence the production of inferences, which for me was perhaps the most important aspect.

These may be summarized as those relating to (1) the actual text; (2) the reading context; and (3) individual differences within the reader.

Components of the actual text are obviously significant, including the vocabulary, sentence length and complexity, and the presence of subheadings and other organizing features. The distance of referents from the relevant antecedents is important in the construction of inferences. This suggests that teachers should begin with examples in which referents are close to their antecedents when explicitly teaching inferencing. Singer reported that readers answered questions more rapidly after a *causal* rather than a temporal sequence (p. 71), which again suggests an order of teaching.

Butcher and Davies reported on factors that facilitated inference making in multimedia and online electronic environments, most of which would be applicable to print-based materials (pp. 330-334). Visual cues (highlighting, colour-coding, increasing font size, using arrows to indicate causation or sequence) and diagrams and graphic organizers have long been used to support comprehension of print-based material. Butcher and Davies found they were potentially useful in supporting comprehension across a number of online electronic resources, but their research revealed important differences in the effectiveness of such visual supports under different conditions and with different populations. These refinements constitute a valuable contribution in that they further the understanding of how precise deployment of supports can make a significant difference to comprehension.

Elements of the reading context, such as associated tasks and instructions can also facilitate or inhibit inferences. Lorch, Jr. (p. 351), and Cook and O'Brien (p. 24) report the powerful effect of having a reading goal that specifically encourages inferences. Noordman, Vonk, Cozijn and Frank demonstrate that a reading-related goal, whether self-imposed or the result of instruction, improves overall processing and the development of inferences (pp. 265-266). Singer, however, found that some researcher-imposed goals, such as proofreading for spelling, act as distractors for readers and disrupt the generation of inferences (p. 85).

Individual differences are clearly of prime importance. We know that skilled readers are more likely to generate elaborative inferences than are less skilled readers because inferences rely on wide background knowledge and well-developed executive processes, both characteristics of the more able reader (Pratt & Yamasaki, p. 211). Developing comprehension skills is a focus in many schools, particularly now that the need for explicit teaching of letter-sound knowledge is permeating schools and the basic decoding abilities of most children are developing rapidly. The expected increase in comprehension scores has not followed in all schools. I have spent much of the past eight years supporting teachers across Australia in the development of the explicit teaching of letter-sound knowledge or *phonics,* which became a lost skill as the whole

language model was introduced in education systems. Teachers have been both surprised and elated at most children's rapid mastery of decoding, but some have been concerned that this did not immediately translate into improved comprehension. Feedback included the point that time spent on teaching phonics was 'wasted' if it did not help reading comprehension. There did not appear to be an appreciation of the many different elements that contribute to comprehension. Many chapters in this book provide new ways of explaining the complexity of comprehension processes compared with the subcomponent skills, and the need for both.

There is wide agreement amongst the authors that inferences are possible only after the basic linguistic processes required for text-level understanding have been mastered. If readers are rapid decoders, have a wide vocabulary and a secure knowledge of syntax to support their initial reading, they will have a 'pool' of resources available for higher level processing. Pratt and Yamasaki provide a clear explanation of the "neural efficiency" model (p. 213): increasing skill at a task is evident in a reduction in the neural activity required for its completion, thus greater neural efficiency in the text-level processes increases the availability of cognitive resources for the more complex and elaborated comprehension processes.

The significance of background or *world knowledge* as a core contributor to inference making is widely discussed, as it is the basis of inferential processing. This varies enormously amongst individuals with the difference in dramatic evidence from the early years of schooling. A particularly relevant component of world knowledge is the *richness of a reader's vocabulary knowledge*: not just word meanings, but how words are pronounced and spelt, their grammatical classification, and the number of related concepts activated when the word is read. The chapter by Oakhill, Cain and McCarthy on inference generation in children, and the different contributions of vocabulary depth and breadth, was particularly helpful in clarifying this component of inference generation.

The *ability to rapidly retrieve* this knowledge is also relevant, which has implications for both *working memory* and *long-term memory capacity*. The ability to *direct attention* appropriately (Van den Broek, Beker & Oudega, p. 106) and to *engage in divergent and convergent thinking* (Gerrig & Wenzel, pp. 378-381) also differentiate individuals' capacity to make inferences. The research of Gygax & Gilioz supports the view that *differences in how readers process affective information* also has an impact on reading comprehension (Chapter 6).

Van den Broek, Beker and Oudega reported studies that suggested language-based differences in *knowledge of genre and text signals* (p. 106) result in different capacities to make inferences in their studies. And unsurprisingly, individual motivation appeared in several chapters as a variable affecting all learning. Noordman, Vonk, Cozijn & Frank also reported that new information is

learned from text only if readers are strongly motivated, which contrasts with the general expectation that students learn easily from text (p. 269).

Each of these factors, drawn from the strong evidence base in each chapter, provides direction for educators regarding the development of inferential skills in students, particularly those who struggle to make sense of much of what they read.

Location in the brain
Ferstl reports on her attempts at identifying the precise location of inference processes within the brain. (She prefaces her chapter with the warning that "some basic neuroanatomical knowledge is assumed" [p. 230], but as a reader with little anatomical knowledge, I found the chapter relatively accessible once I jumped the hurdle of "dmPFC activation".) Could neuroimaging identify the specific regions that were activated when attempting to process inconsistencies? She concluded that an extended language network was involved; and that inferencing overlaps with *Theory-of-Mind* (ToM), a term coined by Premack and Woodruff (1978) to describe the ability of most people to understand the motivation, feelings and behaviors of others, and that these may differ from their own. The term was popularized by Baron-Cohen (see Baron-Cohen, Leslie & Frith, 1985) in his investigation of ToM in individuals on the Autism Spectrum, and his contention that limited or delayed ToM explains many of the communication and social difficulties experienced by individuals with this diagnosis. This prompted another intriguing conversation with colleagues in the special education field. Teaching students on the Spectrum to engage in abstract thinking and empathetic behaviour is an ongoing challenge.

Further research
All chapters conclude with the authors themselves identifying areas of potential research. Several highlight the fact that most research in comprehension is conducted with samples of college students, but *other populations have a greater need, such as children and older readers*. Research in inference making has focused overwhelmingly on narrative structures: *expository texts deserve far greater attention. Understanding how readers process affective information* may prove invaluable in identifying comprehension difficulties, but has received little research attention. Other questions ripe for further research include: Do the same individual differences that affect inferences in text reading also apply to other visual media and listening? Does use of visual media distract from, or facilitate inference generation?

Finally, two issues I have pondered. As interpersonal communication occurs increasingly in short bursts via various electronic means, investigation of inferences in short written communications such as email and social media messaging appears to be of increasing importance. Most workplaces (and many relationships) contain examples of misunderstandings that occur because incorrect inferences have been made on the basis of a few written words.

Emails and text messages are usually fairly short because most people have learnt, often the hard way, that longer ones are rarely read beyond the first few lines. What implications does the flood of short communications that we typically send and receive have for our continued capacity for deep comprehension?

Concluding comments
This text celebrates the achievements of a community of scholars who have contributed a great deal through their own quest for coherence as they seek to understand more about an integral component of reading comprehension. It is a book for researchers, and will serve them well. It also has significant implications for teacher educators and practicing teachers, but most of them would probably not persist in reading it. Converting many of the findings into material teachers could use to develop these processes would be a worthy next step.

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