Compensatory Processes in Reading

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In the reading literature, the concept of compensation is usually discussed in two different contexts. The first is the process of compensation that occurs during online reading—compensations that occur when, during the act of reading, the processing system compensates for inefficient cognitive operations by drawing on other knowledge sources and/or processing operations. There is a considerable literature in the reading field on this type of compensation, which we term online compensation.

A second type of compensation—one much less studied—refers to situations where reading itself is the compensatory mechanism. That is, attention has recently focused on the importance of reading experience as a mechanism of cognitive growth and as a means of building knowledge structures. Recent research has addressed the question of whether exposure to print could—through building knowledge bases and exercising malleable cognitive components—compensate for deficiencies in relatively nonmalleable cognitive capacities, at least in certain domains. There is less evidence on this type of compensation, which we term experiential compensation, but our research group has collected some intriguing correlational data on this issue, which we discuss later. For example, vocabulary growth depends on certain basic abilities to elucidate relations, compare semantic features (Sternberg, 1985; Sternberg & Powell, 1983), and maintain codes in working memory (Gathercole & Baddeley, 1989; Gathercole, Willis, Emels, & Baddeley, 1992). Deficiencies in these basic processes will impair vocabulary growth (see Gathercole et al., 1992). Individuals with deficiencies in these basic
processes will require more exposure to a given word before forming an integrated representation of it in semantic memory. However, greater exposure to print provides more opportunities for inducing the meaning of unknown words from context, and this is true of all readers regardless of their level of basic abilities (Anderson, Wilson, & Fielding, 1988; Nagy, Herman, & Anderson, 1985; Stanovich, 1986, 1993). Thus, the concept of experiential compensation raises the issue of whether greater exposure might compensate for deficiencies in the basic abilities relevant to vocabulary induction. We present some preliminary evidence that suggests the possibility that some experiential compensations might be mediated by exposure to print.

ONLINE COMPENSATION

Contextual Facilitation Processes in Reading

One of the clearest cases of online compensation—and the one on which there exists the most empirical evidence—concerns the compensatory relation between word-recognition efficiency and processes of contextual facilitation that operate during reading. It is now well established that as a reader's word-recognition processes decrease in efficiency, there is a tendency for the reader to rely more on prior textual and sentential context to aid in lexical access. In short, the poorer the word-recognition process, the greater the reliance on contextual information.

The discovery of this online compensation was an experimental surprise—a finding that confounded many reading theorists and was predicted by few investigators when it first appeared in the literature in the late 1970s. In fact, the finding falsified the strong predictions of the major models of reading development that were influential at that time. During the mid-1970s, models of reading acquisition and individual differences in reading ability were dominated by top-down conceptualizations (e.g., F. Smith, 1971) that borrowed heavily from the New Look movement in perceptual research (Henderson, 1987). These models strongly emphasized the contribution of expectancies and contextual information. According to such models, the word-recognition process was heavily penetrated by background knowledge and higher-level cognitive expectancies. Reading theorists were considerably influenced by analysis-by-synthesis models of speech perception and interactive models of recognition that derived from artificial intelligence work in speech perception (Rumelhart, 1977).

With hindsight, the problem here is apparent. The analogy from speech to written language is simply not apt. The ambiguity in decontextualized speech is well known. For example, excised words from normal conversation are often not recognized out of context. This does not hold for written language, obviously. A fluent reader can identify written words with near perfect accuracy out of context. In short, the physical stimulus alone completely specifies the lexical representation in writing, whereas this is not always true in speech. The greater diagnosticity of the external stimulus in reading, as opposed to listening, puts a greater premium on an input system that can deliver a complete representation of the stimulus to higher-level cognitive systems.

One particular prediction derived from the top-down reading models, which turned out to be of considerable importance, concerned individual differences. Theorists who developed top-down models of reading consistently predicted that skilled readers would rely less on graphic cues and more on contextual information than less skilled readers (F. Smith, 1971, 1973, 1975). Smith's well-known hypothesis was that good readers were especially sensitive to the redundancy afforded by sentences, were particularly good at developing hypotheses about upcoming words, and were thus able to confirm the identity of a word by sampling only a few features in the visual array. According to this hypothesis, good readers processed words faster, not because their processes of lexical access were more efficient, but because their use of redundancy lightened the load on their stimulus-analysis mechanisms. In short, the skilled reader was less reliant on graphic cues and more reliant on contextual information than the less skilled reader.

As the child develops reading skill and speed, he uses increasingly fewer graphic cues. (Goodman, 1976, p. 504)

The more difficulty a reader has with reading, the more he relies on visual information; this statement applies to both the fluent reader and the beginner. (F. Smith, 1971, p. 221)

One difference between the good beginning reader and the one heading for trouble lies in the overreliance on visual information that inefficient—or improperly taught—beginning readers tend to show, at the expense of sense. (F. Smith, 1973, p. 190)

It is clear that the better reader barely looks at the individual words on the page. (F. Smith, 1973, p. 190)

The last conjecture has been uniformly contradicted by eye-movement research in the last two decades. Research consistently indicates that the vast majority of content words in text receive a direct visual fixation (Balota, Pollatsek, & Rayner, 1985; Just & Carpenter, 1987; Perfetti, 1985; Rayner & Pollatsek, 1989). Short function words and highly predictable words are more likely to be skipped, but even the majority of these are fixated. In short, the sampling of visual information in reading, as indicated by fixation points, is relatively dense. Likewise, the study of the processing of visual information...
within a fixation has indicated that the visual array is rather completely processed during each fixation. It appears that visual features are not minimally sampled, but are exhaustively processed even when the word is highly predictable (Balota et al., 1985; Rayner & Bertera, 1979; Zola, 1984).

More important, however, is that the theoretical prediction embodied in the first three quotes—that word recognition in the skilled reader will display more contextual dependency—has been decisively falsified by much empirical data. The falsifying data revealed instead a pattern of compensatory processing: It is less skilled readers who appear to be more reliant on contextual information, presumably to speed a process of lexical access that is proceeding slowly on the basis of the stimulus information alone.

Many discrete-trial reaction-time (RT) studies have been conducted to investigate the effect of context on word recognition. Most of these studies have used priming paradigms, where a context (sometimes an associated word, sometimes a sentence, and sometimes several sentences or paragraphs) precedes a target word to which the subject must make a naming or lexical-decision response. Although this paradigm does not completely isolate the word-recognition level of processing (see Balota & Chumbley, 1984; Seidenberg, Waters, Sanders, & Langer, 1984; West & Stanovich, 1982, 1986), it does so more than other methodologies that have been used. The finding has consistently been that poorer readers show somewhat larger contextual effects than do the better readers (Becker, 1985; Ben-Dror, Pollatsek, & Scarpati, 1991; Briggs, Austin, & Underwood, 1984; Bruck, 1988, 1990; Perfetti, 1985; Pring & Snowling, 1986; Schvaneveldt, Ackerman, & Semler, 1977; Schwartz, 1985, 1991; Simpson & Foster, 1986; Simpson, Lorsbach, & Whitehouse, 1983; Stanovich, 1982, 1986; Stanovich, Nathan, West, & Vala-Rossi, 1985; Stanovich, Nathan, & Zolman, 1988; Stanovich, West, & Feeman, 1981; West & Stanovich, 1978; West, Stanovich, Feeman, & Cunningham, 1983).

Some investigators have employed oral-reading error analyses to examine individual differences in the use of context to facilitate word recognition. However, the use of the technique for this purpose is problematic because oral-reading errors often implicate levels of processing beyond word recognition (Bowey, 1985; Kibby, 1979; Leu, 1982; Wixson, 1979). For example, self-corrections, in part, reflect comprehension monitoring. Nevertheless, analyses of initial substitution errors have been used to throw light on the facilitation of word recognition by context, and it is likely that these errors partially implicate processes operating at the word-recognition level. Fortunately, the results of oral-reading error studies largely converge with those of RT studies. When skilled and less skilled readers are reading materials of comparable difficulty (an important control; see Stanovich, 1986), the reliance on contextual information relative to graphic information is often greater for the less skilled readers (Allington & Fleming, 1978; Biemiller, 1970, 1979; Harding, 1984; Juell, 1980; Lesgold, Resnick, & Hammond, 1985; Leu, DeGroff, & Simons, 1986; Nicholson & Hill, 1985; Nicholson, Lillas, & Rzoska, 1988; Perfetti & Roth, 1981; Richardson, DiBenedetto, & Adler, 1982; Simons & Leu, 1987; Whaley & Kibby, 1981).

The results from studies of text-disruption effects, timed text reading, and a variety of other paradigms also display a similar pattern (Allington & Strange, 1977; Biemiller, 1977–1978; Ehrlich, 1981; Lovett, 1986; Nicholson, 1991, 1993; Schwartz & Stanovich, 1981; Stanovich, Cunningham, & Feeman, 1984; Strange, 1979). Thus, the results from a variety of different paradigms indicate that the effects of background knowledge and contextual information attenuate as the efficiency of word-recognition processes increases.

The consistent trend indicating that contextual effects on word recognition decrease as reading skill increases has led several theorists to conceptualize the logic of contextual facilitation on word recognition as compensatory in nature (Perfetti, 1985; Perfetti & Roth, 1981; Stanovich, 1980, 1984, 1986). It is hypothesized that the information processing system is arranged so that when the bottom-up stimulus-analysis processes that result in word recognition are deficient, the system compensates by relying more heavily on other knowledge sources (e.g., contextual information). Thus, "the compensatory assumption states that a deficit in any knowledge source results in a heavier reliance on other knowledge sources regardless of their level in the processing hierarchy" (Stanovich, 1980, p. 63).

Although the compensatory data pattern in studies of context effects is well established empirically, theoretical explanations of the pattern are less well developed. Nevertheless, some progress has been made in elucidating what Bäckman and Dixon (1992) termed the three dimensions of compensatory behavior: (a) whether the compensation is automatic or deliberate; (b) whether the compensating behavior is functional or maladaptive; and (c) whether the compensation is qualitatively, or merely quantitatively, different from the performance of the same task by a noncompensating individual. On the third question, there is a reasonable amount of empirical data, and the results are reasonably consistent. When the word-recognition processes of fluent readers are disrupted—either by using various forms of stimulus degradation or by using more difficult words—the magnitude and pattern of their contextual effects largely mirror those of less skilled readers (Durgunoglu, 1988; Perfetti, Goldman, & Hogaboam, 1979; Perfetti & Roth, 1981; Stanovich & West, 1983; Stanovich et al., 1981), although in some studies there has been a slight tendency for the contextual effects of less skilled readers to be larger even when equated on word recognition efficiency (Stanovich et al., 1984; Stanovich et al., 1988). Thus, contextual compensation appears to be a case of "normal" quantitative adjustment, rather than a qualitative reorganization of subskills. The compensation in contextual facilitation of word recognition does not involve the use of substitutable subskills, but instead "the use of the same skills as the normal population to solve the task at hand" (Bäckman & Dixon, 1992, p. 275).
The issue of whether online contextual compensation of word recognition in reading is automatic has also been addressed in some research. Many priming studies in the late 1970s and early 1980s were interpreted within the context of Posner and Snyder’s (1975) two-process model of expectancy (e.g., Briggs et al., 1984; Neely, 1977; Stanovich & West, 1983; Stanovich et al., 1981; Stanovich et al., 1985; Vitek & Schwantes, 1989). For example, subjects in Stanovich and West’s study named target words that had been preceded by incomplete sentences. The incomplete sentences provided either a congruous context (e.g., “the skier was buried in the”), neutral context (“they said it was the”), or incongruous context (“the bodyguard drove the”) for the subsequent target words (e.g., snow). The contextual effects in these sentence-context experiments were partitioned into a facilitation component (the difference between performance in the neutral context and the congruous context) and an inhibition component (the difference between performance in the incongruous context and the neutral context). According to the Posner-Snyder two-process view, facilitation can arise from an automatic spreading-activation process or an attentional-prediction mechanism, whereas inhibition arises only from the operation of the conscious-attention mechanism. Results indicating that skilled readers displayed contextual facilitation in the absence of inhibition (Stanovich et al., 1981; Stanovich et al., 1985; West & Stanovich, 1978) led to the conclusion that contextual effects were an automatic facilitative mechanism in relatively fluent readers. That this mechanism was compensatory in nature was supported by the finding that contextual effects were larger for words that were more difficult to recognize in isolation (e.g., Stanovich & West, 1981). Conversely, indications that poorer readers displayed contextual inhibition as well as facilitation (e.g., West & Stanovich, 1978) were taken to indicate that contextual effects in the less-fluent reader reflected conscious compensatory strategies. These conclusions are less secure now because subsequent results have not always been consistent with the two-process theory, and because models of expectancy and priming have evolved since the early studies on context effects (see Durgunoglu, 1988; King & Just, 1991; Morris, 1994; Neely & Keefe, 1989; Smith, Besner, & Miyoshi, 1994; Stanovich & West, 1983; West & Stanovich, 1986, 1988). Nevertheless, a more modest conclusion still seems warranted—that contextual compensation of online word recognition during reading is relatively more automatic in the more skilled reader.

On the third dimension of compensatory behavior—whether the compensating behavior is functional or maladaptive—any conclusion drawn must be even more speculative. There is undoubtedly a negative correlation between contextual reliance during word recognition and reading skill. Better readers rely less on context than do less skilled readers. Therefore, signs of contextual dependence are predictive of reading difficulty. But the causal status of this association is less secure. It is well known that poor readers have difficulties with phonological processing (e.g., Rack, Snowling, & Olson, 1992; Siegel & Ryan, 1988; Stanovich, 1988, 1991; Stanovich & Siegel, 1994) and, as a result, are slow to develop decoding skills. Their reliance on context might serve to maintain levels of word-recognition efficiency that are sufficient to sustain comprehension processes. Therefore, the use of context by poor readers might be viewed as an adaptive response. However, a recurring fear often voiced in the reading literature (e.g., Biemiller, 1970; Frith, 1985; Nicolson, 1993; Stanovich, 1980, 1986, 1992) is that such contextual dependence tempts the child to develop a nonanalytic processing style that ultimately interferes with the learning of spelling-sound correspondences.

However, some investigators (e.g., Share, in press; Tunmer & Hoover, 1992) have argued that some level of contextual prediction in early reading acquisition might be efficacious for long-term reading growth because it “facilitates the development of phonological recoding skill by enabling children to use context to identify unfamiliar words, which in turn increases their knowledge of grapheme-phoneme correspondences” (Tunmer & Hoover, 1992, p. 201). However, such a conjecture requires some fine theoretical distinctions—distinctions that probably outrun the empirical evidence. For example, a contextual prediction that maintains the comprehensibility of the passage, but is nevertheless incorrect, will result in a misleading learning trial (see Jorm & Share, 1983; Share, in press; Tunmer & Hoover, 1992) from the standpoint of learning correspondences between orthographic and phonological information. If a contextual prediction aids in decoding the correct orthographic form, only then will it be a mechanism associated with long-term growth in decoding ability, and hence reading skill. Which of these two situations predominates is presently unknown, but most reading researchers probably feel that the greater danger is from too much reliance on context, rather than too little (Adams, 1990; Gough, 1983; McKenna, Robinson, & Miller, 1993; Nicolson, 1993; Stanovich, 1986, 1992). Online contextual compensation—as efficacious as it might be for the current reading act—is, in the long term, more likely to be maladaptive.

**Orthographic and Phonological Coding in Word Recognition**

The second example of online compensation that has been extensively investigated in the reading literature is the trade-off between phonological coding and orthographic coding in word recognition. A strong caveat is in order before discussing this literature, however. Theoretical conceptualization in this area has recently evolved quite markedly with the advent of several influential connectionist models of word recognition (e.g., Brown, 1987; Brown & Watson, 1991; Hinton & Shallice, 1991; Seidenberg, 1992; Seidenberg & McClelland, 1989a, 1989b; Sejnowski & Rosenberg, 1986, 1988; Van Orden, Pennington, & Stone, 1990). In contrast, most of the literature on the compen-
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The relationship of phonological and orthographic coding was developed using the classic dual-route model of lexical access (see later discussion) as a theoretical background. We maintain our understanding of the implicit dual-route language in our discussion, although we acknowledge that theoretical developments in this area are in flux. Nevertheless, the issues are far from resolution, and dual-route architectures remain viable theoretical contenders (Besner, Twilley, McCann, & Seergobin, 1990; Castles & Coltheart, 1993; Coltheart, Curtis, Atkins, & Haller, 1993; Paap, Noel, & Johansen, 1992). However, the discussion of the compensatory relationship would not be drastically altered regardless of the resolving.

As classically formulated, dual-route models (Coltheart, 1978; Forster & Chambers, 1973; Meyer, Schvaneveldt, & Ruddy, 1974) posit two alternate recognition pathways to the lexicon: a direct visual/orthographic access route that does not involve phonological mediation, and an indirect route through phonology that utilizes stored spelling-sound correspondences. The size of the spelling-sound correspondences that make up the phonological route differ from model to model. Versions of dual-route models differ in assumptions about the various speeds of the two access mechanisms involved, and how conflicting information is resolved. Excellent discussions of the many variants of this type of model are contained in several review articles (see Carr & Pollatsek, 1985; Coltheart et al., 1993; Humphreys & Evett, 1985; Paap et al., 1992; Patterson & Coltheart, 1987; Rayner & Pollatsek, 1989). In all such models, the phonological route may or may not become implicated in performance, depending on the status of the other route (Patterson, Marshall, & Coltheart, 1985) and the nature of the words being read. Two important factors in the latter class are the frequency and the spelling-sound regularity of the words used as stimuli. Indeed, studies of the spelling-sound regularity effect in word recognition have become a major source of data for addressing questions about the role of phonological coding in word recognition.

Spelling-sound regularity refers to the consistency of the mapping between the letters in the word and the sounds in its pronunciation. Regular words are those whose pronunciations reflect common spelling-sound correspondences (e.g., made, rope); irregular words are those with pronunciations that reflect atypical correspondences (e.g., sword, pint, have, aisle). Regularity is, of course, a continuous variable, not a discrete category (Barber & Millar, 1982; Patterson & Coltheart, 1987; Rosson, 1985; Venezy & Massaro, 1987), and the issue of how best to define regularity is a complex and contentious issue (Brown, 1987; Henderson, 1982, 1985; Humphreys & Evett, 1985; Kay & Bishop, 1987; Patterson et al., 1985; Rosson, 1985; Venezy & Massaro, 1987). Disagreement about how to classify words in terms of spelling-sound regularity is common because the degree of regularity assigned depends greatly on the size of the coding unit that is assumed for spelling-sound correspondences (Kay & Bishop, 1987). Simply put, many more words are regular when large-unit mappings are employed (Henderson, 1982; Ryder & Pearson, 1980; Treiman, 1992; Venezy, 1970).

Nevertheless, the finding of primary interest to us is not dependent on any of these disputes, because it holds up despite differing definitions of regularity. The finding concerns the so-called spelling-sound regularity effect in word recognition: the tendency for regular words to be read faster and more accurately than exception words. It has been consistently found that highly skilled readers display very small regularity effects, presumably because their fast-acting visual/orthographic access mechanism operates too rapidly for the slower-acting phonological coding process to become implicated in performance (Backman, Bruck, Hebert, & Seidenberg, 1984; Seidenberg, 1985b; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Waters & Seidenberg, 1985). In contrast, poorer readers display much larger regularity effects, presumably because their slower visual/orthographic access route allows time for the phonological coding process to become implicated in performance. Thus, we have a compensatory processing situation similar to that involving context described previously. There, individuals with slower word-recognition processes displayed larger context effects. Likewise, individuals with slower mechanisms of direct visual access display larger effects of the phonological route on word processing.

Some research has addressed Backman and Dixon's (1992) three dimensions of compensatory behavior in this domain. Most investigators view this particular tradeoff in processing subskills as representing an automatic compensation (e.g., Seidenberg, 1985a), but the use of the phonological route may necessitate expenditure of some processing capacity (Paap et al., 1992). As was the case with context effects, the compensatory use of phonological information appears to represent a case of "normal" quantitative adjustment, rather than a qualitative reorganization of subskills for poor readers. When the visual/orthographic route of fluent readers is slowed by using low-frequency words, the magnitude of their spelling-sound regularity effect largely mirrors that of less skilled readers (Backman et al., 1984; Seidenberg, 1985b; Seidenberg, Waters, Barnes, & Tanenhaus, 1984). Finally, there is little direct evidence indicating whether compensatory use of phonological information is functional or maladaptive. However, given the critical role of phonological processing in several different subprocesses of reading (e.g., Siegel & Ryan, 1988; Stanovich, 1986, 1991; Stanovich & Siegel, 1994; Vellutino & Scanlon, 1987), there is reason to believe that it probably represents a functional and adaptive compensation.

EXPERIENTIAL COMPENSATION

In our research program, we have also investigated whether there was empirical evidence for experiential compensation: situations where reading itself served to compensate for other cognitive deficiencies. With respect to
print exposure, there is a curious asymmetry in the research literature. Researchers studying the cognitive psychology of reading have attempted to specify individual differences in the cognitive processes that support efficient reading performance (Carr & Levy, 1990; Daneman, 1991; Just & Carpenter, 1987; Perfetti, 1985; Rayner & Pollatsek, 1989). A popular research strategy has been the cognitive-correlates approach (see Pellegrino & Glaser, 1979; Sternberg, 1990), in which investigators attempt to determine whether individual differences in particular cognitive processes or knowledge bases can serve as predictors of reading ability (e.g., Jackson & McClelland, 1979). The causal model that is implicit in such analyses locates individual differences in the cognitive subprocesses that support the reading act.

In cognitive psychology, little attention has been focused on what might be termed a form of reciprocal causation—that is, on the possibility that differences in exposure to print might affect the development of cognitive processes and declarative knowledge bases. In contrast, for decades anthropologists, sociologists, and historians have been intensely preoccupied with speculations on how the exercise of literacy affects knowledge acquisition, belief systems, cognitive processes, and reasoning (e.g., Goody, 1977, 1987; Havelock, 1963, 1980; Kaestle, 1991; Olson, 1977, 1986; Ong, 1967, 1982; Stock, 1983). It is not clear why the division of labor between cognitive psychologists and other social scientists in the domain of literacy should have developed in such an extreme fashion. Reading is a special type of interface with the environment, providing the organism with unique opportunities to acquire declarative knowledge. Furthermore, the processing mechanisms exercised during reading receive an unusual amount of practice. Certain microprocesses of reading that are linked to words or groups of words are repeatedly exercised. From at least the fifth grade, an avid reader is seeing literally millions of words a year (Anderson et al., 1988). Thus, whatever cognitive processes are engaged over word or word-group units (phonological coding, semantic activation, parsing, induction of new vocabulary items) are being exercised hundreds of times a day. It is possible that this amount of cognitive muscle flexing will have some specific effects. Yet the dominant framework in the cognitive psychology of reading continues to be the cognitive-correlates approach, with its bias toward viewing cognitive processes as causally prior to the reading act, which is almost exclusively perceived as an outcome variable. In our research, we have reversed this pattern by examining the extent to which differences in the exercise of reading skills may be viewed as causally prior to certain cognitive outcomes.

We have spent considerable research effort developing measures of exposure to print that are valid and that can be administered efficiently. However, this part of our research program is tangential to the issues of the present chapter, so the reader is referred to a series of articles in which we established the construct validity of the measures of print exposure that we employ (Allen, Cipielewski, & Stanovich, 1992; Stanovich, 1993; Stanovich & Cunningham, 1992; West & Stanovich, 1991; West, Stanovich, & Mitchell, 1993). Here, we present analyses in which we pit—in a correlational sense—general ability measures against print exposure as predictors of cognitive outcomes in the verbal domain. Although never losing sight of the correlational nature of the data, we may ask, for example, whether print exposure can compensate for modest levels of general cognitive abilities, at least in a statistical sense.

The results of some relevant comparisons are presented in Table 13.1 (see also Stanovich, 1993; Stanovich & Cunningham, 1992). Two groups that were mismatched on print exposure and nonverbal cognitive ability were formed in the following manner. A large sample ($N = 300$) of college subjects was classified according to a median split of performance on the Raven Progressive Matrices and a composite print-exposure measure. The resulting $2 \times 2$ matrix revealed 118 subjects who were discrepant: 56 subjects who were low in print exposure but high on the Raven (LoPrint/HiAbility), and 62 subjects who were high in print exposure but low on the Raven (HiPrint/LoAbility). These two groups were then compared on seven verbal-outcome measures. As indicated in Table 13.1, the HiPrint/LoAbility group outperformed the LoPrint/HiAbility group on every variable in the study, which included two measures of vocabulary (Nelson-Denny and Peabody Picture Vocabulary Tests), two measures of general knowledge, a verbal-fluency task, a spelling measure, and the Nelson-Denny Reading Comprehension subtest. Four of the seven differences were statistically significant. Thus, as regards performance on these measures of declarative knowledge and verbal skill, print exposure was a more potent predictor than a general ability indicator. It appears that low ability need not necessarily hamper the acquisition of vocabulary and knowledge as long as the individual is an avid reader.

<table>
<thead>
<tr>
<th>Variable</th>
<th>LoPrint/HiAbility</th>
<th>HiPrint/LoAbility</th>
<th>$t(116)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson-Denny Vocabulary</td>
<td>14.3</td>
<td>15.5</td>
<td>1.90</td>
</tr>
<tr>
<td>Peabody Picture Vocabulary Test</td>
<td>10.1</td>
<td>12.5</td>
<td>4.11**</td>
</tr>
<tr>
<td>History and Literature (NAEP)</td>
<td>12.1</td>
<td>13.9</td>
<td>3.24*</td>
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<tr>
<td>Cultural Literacy Recognition</td>
<td>.367</td>
<td>.517</td>
<td>6.57***</td>
</tr>
<tr>
<td>Nelson-Denny Comprehension</td>
<td>22.5</td>
<td>23.3</td>
<td>1.34</td>
</tr>
<tr>
<td>Spelling Composite</td>
<td>-.16</td>
<td>.27</td>
<td>2.67*</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>30.6</td>
<td>32.8</td>
<td>1.66</td>
</tr>
</tbody>
</table>

$p < .05$, $**p < .001$. 

**TABLE 13.1**

Differences Between Subjects With High Ability but Low Print Exposure ($N = 56$), and Subjects With Low Ability but High Print Exposure ($N = 62$)
Table 13.2 displays an analysis of an even more unusual mismatch: that between print exposure and reading-comprehension ability. This analysis takes advantage of the fact that, although print exposure is positively correlated with Nelson-Denny Reading Comprehension performance, the relationship is far from perfect. There are individuals who, despite having modest comprehension skills, seem to read avidly; and there are other individuals who, despite good comprehension skills, seem not to exercise their abilities.

What are the cognitive correlates of a mismatch between abilities and the exercise of those abilities? To investigate this issue, the sample was classified according to a median split of performance on the Nelson-Denny Reading Comprehension subtest and a composite print-exposure variable. The resulting 2 x 2 matrix revealed 82 subjects who were discrepant: 38 subjects who were low in print exposure but high in comprehension (LoPrint/HiComp), and 44 subjects who were high in print exposure but low in comprehension (HiPrint/LoComp). These two groups were then compared on all the variables in the study (see Table 13.2). Despite comprehension differences favoring the LoPrint/HiComp group, as well as nonverbal cognitive abilities favoring this group (they were also higher on the Raven), LoPrint/HiComp individuals were not superior on any of the other variables. In fact, on one measure of vocabulary (the Peabody Picture Vocabulary Test) and one measure of general knowledge (a cultural literacy test), the HiPrint/LoComp group performed significantly better. Although inferences from these correlational analyses must be tentative, the results do suggest that low ability need not necessarily hamper the development of vocabulary and verbal knowledge as long as the individual is exposed to a lot of print.

In another study (Stanovich & Cunningham, 1993), we found that measures of general knowledge were more strongly associated with print exposure when it was mismatched with reading-comprehension ability. A sample of 268 college subjects was classified according to a median split of performance on the Nelson-Denny Reading Comprehension subtest and on measures of print exposure. The resulting 2 x 2 matrix revealed 77 subjects who were discrepant: 44 subjects who were below the median in print exposure but scored above the median on the Nelson-Denny (LoPrint/HiComp), and 33 subjects who were high in print exposure but were low on the Nelson-Denny (HiPrint/LoComp). These two groups were then compared on five measures of general declarative knowledge. There were differences favoring the HiPrint/LoComp group on all five measures, and three of these differences were statistically significant (see Stanovich & Cunningham, 1993). The results suggest that low comprehension ability does not necessarily lead to low levels of knowledge as long as an individual has considerable print exposure.

In a final study illustrating experiential compensation (Stanovich, West, & Harrison, in press), we compared the performance of 133 college students (M = 19.1 years of age) and 49 older individuals (M = 79.9 years of age) on two general knowledge tasks, a vocabulary task, a working memory task, a syllogistic reasoning task, and several measures of exposure to print. The older individuals outperformed the college students on the measures of general knowledge and vocabulary, but did significantly less well than the college subjects on the working memory and syllogistic reasoning tasks.

Much attention has focused on the psychometric theory of fluid-crystallized intelligence in the study of intellectual growth and decline (Carroll, 1993; Horn, 1982; Horn & Cattell, 1967; Horn & Hofer, 1992; see also Baltes, 1987; Smith & Baltes, 1990). Fluid abilities are processes such as memory and reasoning, which operate across a range of domains and which are posited to be relatively independent of specific environmental experiences. In contrast, "crystallized abilities are postulated to reflect one's experiential history, and are assessed by tests of vocabulary, general information, and nearly all types of acquired knowledge" (Salthouse, 1988, p. 239). Fluid abilities are known to decline substantially with age, whereas crystallized abilities either decline much less or exhibit continual growth throughout most of the adult years (Baltes, 1987; Horn, 1982; Horn & Donaldson, 1980; Horn & Hofer, 1992). The results from Stanovich et al. (in press) were consistent with this trend in the literature for crystallized abilities, which are presumably reflected in the knowledge and vocabulary measures, to continue to grow with age, and for measures of fluid ability, which are presumably reflected in the working memory and syllogistic reasoning measures, to decline with age. However, a series of hierarchical regression analyses indicated that when measures of exposure to print were used as control variables, the positive relationships between age and vocabulary, and age and declarative knowledge, were eliminated (in contrast, the negative relationships between age and fluid abilities were largely unattenuated). The results suggest that, in the domain of verbal abilities, print exposure helps compensate for the normally deleterious effects of aging.
In terms of characterizing the experiential compensation of reading, in terms of Backman and Dixon's (1992) three dimensions of compensatory behavior, the situation is clear with respect to two of the three dimensions. The compensating behavior is clearly functional. It is also somewhat clear that the compensation is quantitative, rather than qualitative, in nature. That is, no one has demonstrated that individuals high in print exposure think in a qualitatively different way than individuals low in print exposure. Although there have been conjectures that the cognitive processes of completely illiterate individuals might be qualitatively different from those of literates (e.g., Olson, 1977, 1986, 1994), these conjectures are still controversial and, in any case, do not represent the comparison that we have examined in our work. On the third dimension—of whether the compensation is automatic or conscious—a few conceptual distinctions are necessary. First, the act of reading is certainly engaged in as the result of a conscious decision by the subject (i.e., it is not always a mindless act; see Brown & Langer, 1990). So clearly the decision to engage in reading is sometimes conscious. However, the effects of the reading behavior on cognitive processes may, in fact, arise as an automatic side effect of reading. Again, the extent to which knowledge building during reading is a conscious or automatic process (e.g., is the induction of a new vocabulary item from context conscious or automatic?) is a largely uninvestigated issue.

SUMMARY

In the area of reading, two different types of psychological compensation have been investigated: online compensation and experiential compensation. Two examples of online compensation that have been extensively studied were examined in this chapter. The compensatory use of contextual information to supplement inefficient word-recognition processes appears to be a "normal" use of a compensatory mechanism, in the sense that it does not involve the use of substitutable subskills, but instead represents the use of the same skills as the normal population to aid processing. Such a compensation is probably automatic in most cases, but is probably maladaptive at the higher levels of reading skill. The compensatory use of phonological information to aid the visual-orthographic route during word recognition is, in contrast, probably an adaptive compensation. It too, is probably primarily an automatic compensation.

The long-term, experiential, compensatory effects of reading behavior have recently become the subject of empirical investigation. So far, all of the experiential compensations involving print exposure have been adaptive in nature. It appears that, as regards the development of declarative knowledge bases such as vocabulary, a large amount of exposure to print can compensate for modest levels of general comprehension abilities. Likewise, it appears that the absence of normally deleterious effects of aging in the domain of crystalized abilities is due, to some extent, to the compensatory effects of print exposure.

ACKNOWLEDGMENTS

This research was supported by grant R#410-92-0397 from the Social Sciences and Humanities Research Council of Canada to Keith E. Stanovich, by a James Madison University Program Faculty Assistance Grant to Richard F. West, and by a James S. McDonnell Foundation Postdoctoral Fellowship to Anne E. Cunningham.

REFERENCES


13. COMPENSATORY PROCESSES IN READING


Compensation in Athletic Sport

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This chapter examines compensation in athletic sport. Bäckman and Dixon (1992) described a general model of compensation that is composed of components of external demand, personal expectation of performance, and accessible skill. They reasoned that compensation begins with a mismatch between demands and skill, with performance expectations initially matched to demand. Faced with an imbalance between demand and skill, three classes of option are available. First, a person can try to compensate by changing skill to match demand. Possible mechanisms include raising the level of effort, using latent aspects of skill, or finding an alternative skill. A second category of option is to compensate by changing expectations to match skill rather than demand. Third, noncompensatory options are not to change behavior at all, but to acquiesce with grace or rancour to the demand-skill discrepancy. Unlike the latter, both the compensatory options involve behavioral change that restores the balance between skill and expectations.

Bäckman and Dixon emphasized three clarifications to the preceding scheme. First, only behaviors arising from a demand-skill mismatch exemplify compensation. Second, such a mismatch does not always result in compensatory behavior. Third, they suggested the behavior to be different between a compensating person and a normal person in a given situation. The latter raises some intriguing issues for research design.

Successful athletes are supranormal in their expertise, being both selected for ability and extensively trained for technique and fitness. Appropriate referents for aging athletes include equally gifted but younger peers, or their...