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ABSTRACT

This study compared the central capacity and the modularity models for explaining language processing in kindergarten children. Using a microcomputer, 19 kindergarten children completed a visual letter-matching task that required a manual response. An auditory tone was emitted by the computer in a separate trial also requiring a press. For the dual task block, three stimulus onset asynchronies (SOAs) of 200, 400, and 1,000 milliseconds were randomly used to introduce the auditory tone. Each subject was individually instructed in response techniques and was individually tested. Ten of the subjects were tested for a second and third session. Response times were measured and recorded by the microcomputer. Results indicated that reaction time was significantly increased when one task was interrupted by another task. Reaction time to a tone was significantly affected by: (1) SOAs or the time interval used; (2) the letter match task of same or different letters; and (3) the session. Reaction time to a tone was not significantly affected by interactions between or among the factors. These results suggest that attention-demanding tasks may be postponed during serial processing. The explanation of refractoriness as demonstrated by a postponement or bottleneck in central capacity would seem tenable. (MM)

The Psychological Refractory Period: Central Capacity versus Modularity as Related to the Processing of Language

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Objective

The purpose of this study was to compare the central capacity and the modularity models for explaining language processing. The effects of single and dual task demands on the refractory period, the time required to respond, were compared in kindergarten children. The children's reaction time to each type of task was measured.

Perspectives

The information processing perspective views the cognitive system as an intricate, symbol-manipulating entity through which an environmental input flows to culminate in a behavioral response. As a language activity, reading requires that information be integrated and that reponses be made to continuous stimuli. Since reading involves overlapping tasks of orthography, phonology, semantics, and context, a series of reactions must be combined. This integration requires a certain amount of time known as the psychological refractory period. After the initial stimulus input, this temporal period must pass before a response to a second stimulus can begin. This process has been explained by two models, central capacity and modularity.

For language processing, the central capacity model proposes that information is processed at various stages. Resources are sequentially channeled from input to output within the cognitive system. Evidence includes research by Pashler (1990) and Pashler and Johnston (1989) who found that when a combination of manual and vocal responses was required for completion of a dual task,

reaction time increased significantly as the tasks competed for attention. This would imply a postponment or central bottleneck within the information processing network.

In reading, LaBerge and Samuels (1974) assumed that because most postlexical comprehension processes are resource demanding, a reallocation of unneeded central capacity would be required. This reallocation would take place through acquired automaticity of lexical access. Automatization was seen as a gradual withdrawal of attentional participation (Logan, 1985). For reading, an automatic pattern of spreading activation is thought to generalize to word recognition and sentence processing in elementary school readers (Stanovich & West, 1983). Automatic cognitive processes may expedite the channeling of resources needed for the temporally overlapping elements of orthography, phonology, semantics, and context in reading.

In contrast, the theory of modularity suggests that the period of delay or refractoriness is created by informationally encapsulated subsystems with autonomous operating functions. Highly specialized modules of perception, action, and language operate within the cognitive network (Fodor, 1983; Van Geert, 1986). An important component of encapsulation or separation is the presence of a distinct representation in memory that permits autonomous access. Brooks (cited in Baddeley, 1986) discovered a clear interaction between the type of memory task and the mode of response. There was interference related to modality-specific demands.

For reading, the theory of modularity proposes the

development of an autonomous lexicon. Perfetti and McCutchen (1987) suggest that orthgraphic and phonological representations within the lexicon may be accessed without background knowledge or contextual expectations. A longitudinal study of reading acquisition proposed that a phonological subsystem within the language module of preschoolers promoted reading skill (Stuart & Coltheart, 1988). Thus, the theory of modularity implies a network of informationally encapsulated subsystems. Autonomous operating functions are modality specific and are capable of accessing distinct representations in memory.

No research has been found which examines the effect of cross-modality tasks on the language processing of very young children. This study examines the role of the psychological refractory period by exploring the single and dual task processing strategies of beginning readers.

Method

Subjects were kindergarten students aged 5 1/2 to 6 1/2 years, including 10 boys and 9 girls. A Packard Bell 386 SX microcomputer was used to present a visual letter matching task which required a manual response. An auditory tone was emitted by the computer is a separate trial also requiring a press. A combination or dual task trial necessitated a press of a button to cease the auditory tone followed by a decision regarding the letter match task. For the dual task block, 3 stimulus onset asynchronies (SOAs) of 200, 400, and 1000 milliseconds were randomly used to introduce the auditory tone. Each subject was individually instructed in response techniques and was

individually tested. Ten of the 19 subjects were tested for a second and a third session. Response times were measured and recorded by the microcomputer.

Results

An analysis of variance (ANOVA) was performed on the dependent variable of reaction time. The independent variables or factors were the tasks of letter match and of tone response. A 2 (letter match only, letter match with tone) by 2 (tone response only, tone response with letter match) ANOVA was computed. The letter match reaction time was significantly affected when the tone was present ($F = 21.44$, $p < .001$). The tone reaction time was significantly affected when the letter match was present ($F = 41.58$, $p < .001$). The interaction of the tasks of letter match and tone response was nonsignificant. Thus, when the task was interrupted, reaction time was significantly increased. Secondly, a 2 (letter match task: same or different letters) by 3 (SOAs: 200, 400, 1000 milliseconds) ANOVA was performed in which the dependent variable was tone reaction time. The reaction time to the tone was significantly affected by the SOAs ($F = 13.71$, $p < .001$). Neither the letter match task nor the interaction of letter match by SOAs were significant. Finally, a 2 (letter match task: same or different letters) by 3 (SOAs: 200, 400, 1000 milliseconds) by 3 (session: first, second, or third) ANOVA was performed. The dependent variable was reaction time to the tone. The letter match task significantly affected reaction time ($F = 8.80$, $p < .006$) as did session ($F = 12.71$, $p < .001$). SOAs were not significant. None of the interactions was significant.

In summary, findings indicated: a) reaction time was significantly increased when one task was interrupted by another task; b) reaction time to a tone was significantly affected by SOAs or the time intervals used; c) reaction time to a tone was significantly affected by the letter match task of same or different letters; d) reaction time to a tone was significantly affected by session; and e) reaction time to a tone was not significantly affected by interactions between or among the factors.

These results suggest that attention-demanding tasks may be postponed during serial processing. The explanation of refractoriness as demonstrated by a postponment or bottleneck in central capacity would seem tenable.

Educational Importance

Implications for educational practice include recognition of the principle of refractoriness or time delay. Teachers of young children should allow adequate processing time for responses to continuous stimuli. Since cognitive processing is subject to temporal limitations, the overlapping elements of orthography, phonology, semantics, and context in reading may be strengthened by acquired automaticity. Experiences which promote print awareness and oral and written expression may enhance automatic processes by effectively channeling cognitive resources. More research would be helpful.

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