22

CHAPTER

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The Broader Context of Craik's Self-Initiated Processing Hypothesis

I am delighted to participate in the conference and contribute to the resulting volume honoring Gus Craik, who is widely recognized as a leading experimental psychologist investigating both basic processes in memory and the effects of increased age on memory. I have long been an admirer of Craik's creative experiments and intuitively appealing theoretical interpretations, and like many others I have enjoyed and benefited from collaborations with him, in my case as a coeditor of the first and second editions of the *Handbook of Aging and Cognition* (Craik & Salthouse, 1992, 2000). Because he is as nice interpersonally as he is esteemed scientifically, I can think of no person more deserving of this type of recognition.

This event is intended to commemorate Gus's retirement from the University of Toronto, and it is often appropriate when such a distinguished individual completes an important phase of his career to attempt to classify and evaluate his contributions. I will leave it to others to evaluate his contributions, and instead I will attempt a preliminary classification of where he stands with respect to major schools or systems within psychology. Although Craik is indeed an outstanding experimental psychologist, I suggest that he may have at least as much in common with Charles Spearman, one of the pioneers of psychometric or individual difference psychology, as with Wilhelm Wundt, who is often considered the founding father of experimental psychology.

I will explain this perhaps surprising claim by first describing two broad approaches that have been used to investigate and explain adult age differences in memory and other aspects of cognitive functioning. One approach can be characterized as largely analytical and specific, in that it is designed to seek interpretations based on processes hypothesized to be involved in the task under investigation. The second approach is more general, in that it tends to emphasize influences that have an impact at a level broader than that of individual variables.

Most research concerned with adult age differences in memory has focused on variants of the specific approach because the goal has been to decompose or fractionate the task to identify constituent processes, and then determine the magnitude of the age-related effects on each process. This *micro* approach has frequently been successful in identifying processes with differential sensitivity to advancing age. For example, age-related effects are typically greater on controlled processes than on automatic processes, and on processes associated with explicit memory than on processes associated with implicit memory. The micro perspective is represented in this volume by the contributions of Jacoby, Marsh, and Dolan (chapter 19); McDowd (chapter 11); Naveh-Benjamin (chapter 15); and Koustaal and Schacter (chapter 30).

The alternative *macro* approach tends to emphasize age-related effects that operate on several different types of variables. These broader influences may be related to effects on a critical process or theoretical construct, such as encoding or goal maintenance, or they may be linked to an attribute such as working memory capacity, effectiveness of deploying or inhibiting attention, or speed of processing. The common feature of these more general perspectives is that they postulate that at least some of the age-related effects on a given variable are not specific to that variable, but instead are shared with several different kinds of variables.

Figure 22.1 contains a schematic illustration of the micro and macro perspectives in cognitive aging. The top panel portrays the decomposition of a variable into a number (in this case, three) of hypothesized processes or components, and the bottom panel represents age-related effects operating on several different types of cognitive variables.

Although much of Craik's research has attempted to fractionate memory tasks to isolate the age-related effects to specific processes, he has also been sympathetic to, and sometimes even an ardent advocate of, the macro or general perspective because he has hy-

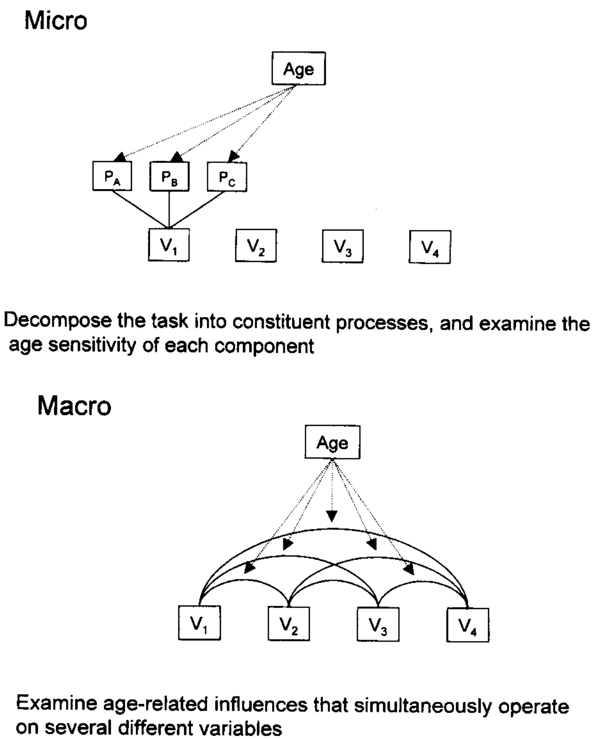

FIGURE 22.1. Schematic illustration of micro (decompositional) and macro (integrative) approaches to investigating adult age differences in cognition.

pothesized that in addition to task-specific processes, there are also age-related influences on some form of processing resource that is needed for the effective performance of many different types of memory tasks. Craik can therefore be considered similar to Spearman (e.g., 1927) because both he and Spearman have argued that individual differences in variables representing different cognitive tasks or abilities are attributable to a combination of general and specific influences. Spearman and Craik are also similar in that both have used the term *mental energy* to refer to the basis of individual differences in the general influences. However, they differ in their proposals about what it is that varies across people and across variables.

As most psychologists know, Spearman proposed the concept of *g*, which refers to the general factor manifested in different degrees across most variables and which is presumably related to the amount of mental energy available to an individual. Craik's equivalent of *g* is self-initiated processing (sometimes referred to as SIP), which he hypothesized is required in different amounts across different types of memory tasks, and which is also presumably related to the amount of mental energy an individual possesses. Craik (e.g., 1986) portrayed his self-initiated processing hypothesis in the form of a table in which the rows represented different memory tasks and the columns indicated that as the amount of self-initiated processing increased, so did the expected magnitude of the age-related differences. A major goal of the hypothesis was to account for an ordering of the magnitude of age differences in memory variables, ranging from priming with the smallest differences, with progressively larger differences for relearning, recognition, and cued recall, and finally the largest age differences for free recall. Another aspect of Craik's self-initiated processing hypothesis is the notion of environmental support because successive positions along the self-initiated processing dimension were postulated to be associated with varying amounts of environmental support. This support existed in the form of cues, context, etc., that serve to reduce the amount of self-initiated processing required to perform the task, and hence also to decrease the magnitude of the resulting age-related differences.

Craik's self-initiated processing hypothesis is intriguing because it implies that memory aging phenomena might be explained once the nature of self-initiated processing was understood. The concept of self-initiated processing shares some similarities with a number of other proposals such as controlled processing, effortful processing, deliberate processing, and reflective processing. In every case, memory or other cognitive tasks are hypothesized to differ in the amount of this processing needed for successful performance, and on average, the effectiveness of carrying out this type of processing is postulated to decrease with increasing age. Each of these proposals has plausibility, but they all face the difficulties of how to operationalize the relevant construct and how to obtain independent measures of the construct to avoid problems of circularity in which the existence of the construct is inferred from the same pattern of results that it is supposed to explain.

Craik and his colleagues have recognized these issues and have attempted to deal with them in a number of ingenious experiments. For example, Craik and McDowd (1987) found that when research participants were asked to perform a reaction time task during a memory task not only were older adults slowed more than young adults by the requirement to perform the two tasks simultaneously, but the reaction times in both groups were larger for a free recall memory task than for a recognition memory task. These results were replicated and extended in a series of experiments by Anderson, Craik, and Naveh-Benjamin (1998), in which the secondary reaction time costs decreased from free recall to cued recall to recognition. The discovery that the magnitude of age differences on a series of memory tasks can be predicted from a variable (i.e., secondary task reaction time) presumed to reflect self-initiated processing demands provides impressive support for Craik's self-initiated processing hypothesis.

In the remainder of this article I will describe a different approach to the study of adult age differences in memory and other cognitive variables. I will start with a quite different question and will rely on a different methodological approach, but I will end up with an empirical function similar to that implied by Craik's self-initiated processing hypothesis. In order to highlight the correspondence between my approach and the Craikian self-initiated processing hypothesis, I will first transform Craik's hypothesis into the graph portrayed in Figure 22.2 in which self-initiated processing and age are positively related to one another, and different memory variables are located at different positions along the function. Note that this representation embodies the key principle of Craik's hypothesis, namely, that there is a systematic relationship between the amount of self-initiated processing required and the magnitude of the age differences on the variable, but it is easier to illustrate the similarity to my approach with this form of representation.

A fundamental assumption of my perspective is that all variables have at least two types of age-related influences: unique influences that are specific to a particular variable and shared influences that are common to many different types of cognitive variables. I also assume that not only do variables differ in the total magnitude of their relation with age but also in the relative contributions of the two types of influences, such that some variables primarily have unique age-related influences, whereas other variables have largely shared influences.

Several analytical methods can be used to estimate the relative contributions of the two

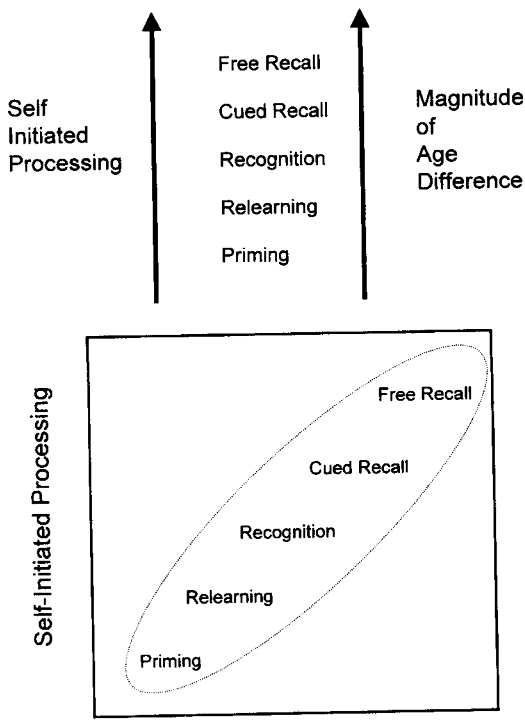

FIGURE 22.2. Alternative representation of Craik's self-initiated processing hypothesis.

types of influences, but it is simplest to illustrate how the estimates can be derived with what can be termed the shared influences method (see Salthouse, 1998; Salthouse, Hambrik, & McGuthry, 1998). The first step in this procedure is to obtain an estimate of the variance that all variables have in common. This can be achieved with a variety of statistical procedures such as principal components analysis, factor analysis, or structural equation modeling. The next step in the procedure is to control an estimate of this common variance before examining age-related effects on individual variables. Effects of age on individual variables in this type of analysis that are evident after controlling what the variables have in common correspond to direct or unique age-related effects, whereas effects that are mediated through the common factor represent shared effects. This analytical method is not necessarily informative about the nature of what is shared among different cognitive variables, but it does provide a means of allowing age-related influences to be partitioned into unique (direct) and shared (indirect) aspects.

Application of the method can be illustrated with data from a study by Salthouse, Fristoe, and Rhee (1996), which involved 259 adults between 19 and 94 years of age. A total of 14 variables were examined in this study, including three measures of episodic memory from

TABLE 22.1. Proportions of total, shared, and unique age-related variance from study by Salthouse, Fristoe, and Rhee (1996).

	Age-related variance (r^2)		
Variable	**Total**	**Shared**	**Unique**
RVLT2	.220	.217	.003
RVLT6	.199	.196	.003
Recog	.108	.096	.012
PA1	.261	.257	.004
PA2	.123	.114	.009
WCST	.167	.166	.001
TrailsA	.256	.256	.000
TrailsB	.348	.344	.004
Shipley	.199	.184	.015
BlkDes	.219	.216	.003
ObjAssm	.170	.167	.003
DigSym	.429	.418	.011
LetCom	.243	.241	.002
PatCom	.436	.395	.041
Median	.220	.220	.004

Note: RVLT2 refers to the number of words recalled in the second trial of the Rey Verbal Learning Test; RVLT6 to the number of words recalled in the sixth (postinterference) trial of the Rey Verbal Learning Test; Recog to the score in the recognition test of the Rey Verbal Learning Test; PA1 and PA2 to the number of response terms correctly recalled in two lists of paired associates; WCST to the number of categories completed in the Wisconsin Card Sorting Test, TrailsA and TrailsB to the time needed to complete versions A and B, respectively, of the Trail Making Test; Shipley to the abstraction (series completion) score from the Shipley Institute of Living Scale; BlkDes to the block design score from the WAIS-R; ObjAssm to the object assembly score from the WAIS-R; DigSym to the digit symbol substitution score from the WAIS-R; LetCom to the number of items completed in the letter comparison test; and PatCom to the number of items completed in the pattern comparison test. See original article for details on these tests.

the Rey Auditory Verbal Learning Test: free recall on the second trial, free recall after an interference list, and recognition. The estimate of the common variance in the shared influence analysis was based on the (unrotated) first principal component obtained from a principal components analysis on the 14 variables. Table 22.1 contains the total age-related variance and the estimates of shared and unique age-related variance for each variable. Notice that the median proportion of age-related variance across the 14 variables was .220, which corresponds to an age correlation of -.47. However, the median proportion of unique age-related variance was only .004, which is less than 2% of the total age-related variance and corresponds to an (absolute) age correlation of .06. The results summarized in Table 22.1 are typical of many analyses of this type because it has frequently been found that only a small proportion of the total age-related effects on a given variable are unique to that variable and independent of the age-related effects on other variables (e.g., Salthouse, 1998, 2001; Salthouse, et al., 1998).

An interesting implication of the finding that a large proportion of the age-related effects on one variable is shared with the age-related effects on other variables is that there should be a positive relation between the magnitude of the age relation on a variable and the degree to which that variable is related to other variables. That is, if large proportions of the age-related effects on different cognitive variables are shared, then the magnitude of the age relation on a variable should closely correspond to the degree to which that variable is related to, or has aspects in common with, other variables. Stated somewhat differently, if a substantial amount of the age-related effects on a particular variable is mediated through a factor representing what is common to all variables, then the size of the age relation for that variable should be proportional to the strength of the relation between the target variable and the common factor. This reasoning leads to the prediction that there should be a strong positive relation between the absolute magnitude of the age relation on the variable and the degree to which that variable is related to other variables. I refer to these predicted functions as AR functions because the axes represent relations of the variable to age (A) and to relatedness (R).

The prediction of positive AR functions across different combinations of cognitive variables has recently received a considerable amount of empirical support. For example, Figure 22.3 illustrates the AR function with data from 14 variables in the Salthouse et al.

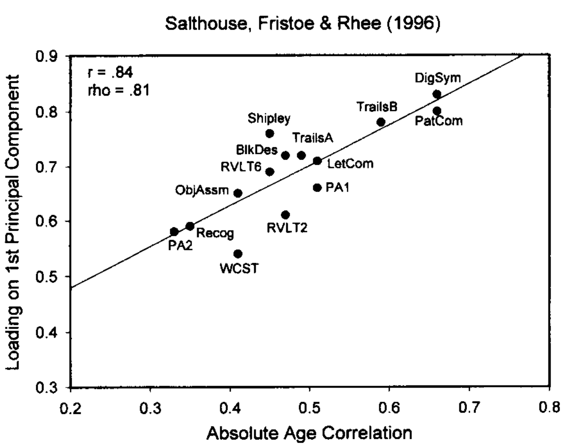

FIGURE 22.3. Variables plotted in terms of their absolute correlation with age (horizontal axis) and their degree of relatedness to other variables (vertical axis). Data from Salthouse, Fristoe, and Rhee (1996).

(1996) study (see Table 22.1 for a description of the variables). Each point in this figure corresponds to a single variable, with its absolute correlation with age along the abscissa and its loading on the first principal component, representing what is statistically common to all variables, along the ordinate. Note that there is a clear positive relation between the two sets of values, as the Pearson *r* was .84 and Spearman's rank-order *rho* correlation was .81.

A similar pattern was evident in a later study by Salthouse, Toth, Hancock, & Woodard (1997), involving an independent sample of participants and a different combination of variables. The data from this study are illustrated in Figure 22.4, where it can be seen that the Pearson *r* was .83 and Spearman's rank-order *rho* correlation was .93. An interesting aspect of this latter study was that it included measures of automatic and controlled processing in a stem completion memory task derived from Jacoby's (1991) process-dissociation procedure. Although the measure of controlled processing (i.e., Stem-Cont) was located close to the center of the AR function and thus can be considered similar to other variables, the measure of automatic processing (i.e., Stem-Auto) was a clear outlier from the function, indicating that the variable had little or no relation to other variables. This finding is therefore consistent with the assumption that automatic processing represents a qualitatively different type of processing than that involved in many variables, and that age-related effects are minimal to nonexistent in the effectiveness of automatic processing. It is important to note that the automatic processing variable in this study had a respectable level of reliability (i.e., .82), and thus its lack of relation to age and to other variables cannot be attributed to a low level of systematic variance (i.e., reliability) available to be shared with other variables.

Similar patterns of positive AR functions are evident in other studies from my laboratory, as the median rank-order correlation across 30 different data sets was .80, and the phenomenon is not an artifact of differential reliability of the variables because the correlations were nearly the same magnitude after partialling estimates of reliability (see Salthouse, 2001). Moreover, the phenomenon is not restricted to data from my laboratory because it is evident in analyses of data from other investigators. Data from two recent large-scale studies by Park and her collaborators can be used to illustrate this point. A

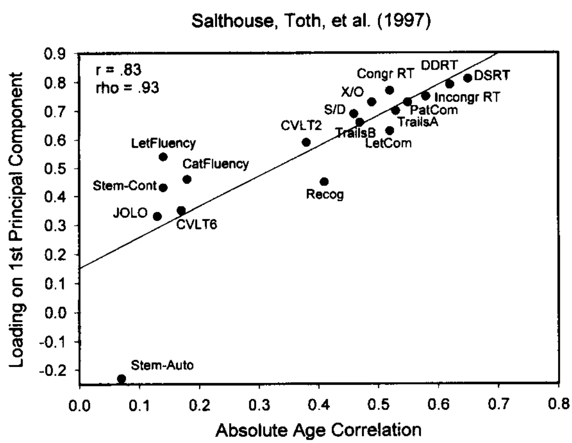

FIGURE 22.4. Variables plotted in terms of their absolute correlation with age (horizontal axis) and their degree of relatedness to other variables (vertical axis). Data from Salthouse, Toth, Hancock, and Woodard (1997).

study published in 1996 (Park et al., 1996) contained data on 11 variables from 301 adults and yielded a Pearson *r* of .54 and a Spearman rank-order *rho* correlation of .52. A study reported in 1998 (Park, Davidson, Lantenschlager, Smith, & Smith, 1998) contained data on 13 variables from 345 adults, and yielded a Pearson *r* of .88, and a Spearman *rho* of .91.

It should be apparent that these empirical AR functions closely resemble the relations predicted by Craik's self-initiated processing hypothesis, as portrayed in Figure 22.2. In both cases the horizontal axis represents the absolute magnitude of the relation of the variable to age. The vertical axes in the two types of functions differ, because with the hypothetical self-initiated processing functions, the axis corresponds to the amount of self-initiated processing, and with the empirical AR functions the axis corresponds to how closely related the variable is to other variables. However, the two situations may be similar in that in each case the vertical dimension can be interpreted as representing the degree of reliance on aspects of processing common to many different types of cognitive variables. That is, the vertical axis in both functions may reflect the need to develop and execute a sequence of processing operations that require the control or allocation of attention. The hypothetical construct of self-initiated processing represents this capability directly, whereas the empirically determined relatedness index may represent it indirectly if it is assumed that variables are related to one another to the extent that they rely on controlled or deliberate processing.

The discovery of positive AR functions can therefore be interpreted as empirical evidence consistent with Craik's self-initiated processing hypothesis. As Craik has predicted, the age differences are larger when there is greater reliance on something necessary for effective performance on different memory tasks. However, it should also be noted that the results I have described suggest that Craik's self-initiated processing hypothesis represents only a limited portion of a broader phenomenon. That is, positive AR relations are not restricted to memory variables, and in fact, memory variables tend to be located toward the lower left region of AR functions. Across a number of analyses of this type, involving a mixture of different kinds of cognitive variables, the upper right region of the function is usually occupied by variables derived from reasoning tasks and perceptual speed tasks (see Salthouse, 2001). This finding also seems consistent with the controlled processing interpretation of AR functions because reasoning tasks can be assumed to require controlled processing to assemble a novel sequence of processes to solve a problem, and perceptual speed tasks require controlled or effortful processing to ensure efficient execution of a simple sequence of processing operations.

In conclusion, despite the dominance of the micro or task-oriented perspective in contemporary cognitive aging research, there is considerable evidence that at least some age-related effects on memory and other cognitive variables are shared and are not completely specific to a particular task. Explanations are therefore needed to account for both shared (or general) and unique (or specific) age-related effects in cognitive aging. The discovery of strong positive relations between the magnitude of the age relation on a variable and the degree to which the variable shares variance with other variables (i.e., AR functions) may provide a valuable window into understanding the basis for shared age-related influences. Furthermore, one promising candidate that might account for these general effects is Craik's notion of self-initiated processing because the dimension underlying the AR functions may correspond to the amount of controlled or self-initiated processing required by a task.

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