1

Cognitive Limitations in Aging and Psychopathology:

An Introduction and a Brief Tutorial to Research Paradigms

Randall W. Engle, Grzegorz Sedek, Ulrich von Hecker, and Daniel N. McIntosh

After a brief presentation of this book's structure and the questions that served to organize the material, we describe the basic research paradigms used in the research from the various chapters. The essence of the theoretical models and the value of empirical evidence is best articulated by the authors of thematic chapters, so we do not summarize them here. However, we do not want arcane terminology or a lack of knowledge of the specific methods on the reader's part to prevent researchers outside of the area from understanding the ideas presented here. Therefore, to make the material more accessible to students and to researchers outside mainstream cognitive psychology, we offer a brief tutorial on the various methods.

At the outset of this project, we tried to preserve an integrative approach by explicitly asking each author to address the same questions. The following set of issues and questions was proposed to be addressed by all authors:

Question 1: *Which cognitive functions are the focus of your research?* In response to this question, authors either provided a description of their own original models of working memory or executive functions, or they elaborated on more specialized executive functions or processes such as inhibition, attention control, or reasoning that they investigated. Authors were asked to review in the general introduction of their chapter the most important theoretical approaches related to their own field before presenting their approach in detail.

Question 2: *Which processing limitations and/or sources of individual differences in cognitive functions are most important in your research?* This was the core question for the genesis of this volume. We were interested in a deeper understanding of the similarities and differences in mechanisms of such limitations among populations studied in cognitive aging and cognitive psychopathology areas.

Question 3: *What are your specific methods and findings?* Authors were asked to describe in some detail the classical, new, or modified research methods applied or developed in their recent studies.

Question 4: *What are the implications of your research for other related research domains?* Authors were asked to formulate implications and new research questions relevant to more general models of working memory or for neighboring fields of cognitive impairment or limitation.

The 13 thematic chapters of this volume are organized in three separate but inherently interrelated sections, concerning: (a) working memory and cognitive functions; (b) cognitive control; and (c) attention, inhibition, and reasoning processes. Each section includes chapters that analyze cognitive processes in either aging or psychopathology. We hope this organization will stimulate collaboration between "cognitive agers" and "cognitive psychopathologists" on functioning across group and individual differences.

The opening thematic chapter (Unsworth, Heitz, & Engle, Chapter 2) and the final thematic chapter (von Hecker, Sedek, Piber-Dabrowska, & Bedynska, Chapter 14) exemplify well the main message of this volume. Namely, there is value in cross-talk among compartmentalized cognitive sciences, such as cognitive psychology, cognitive aging, cognitive psychopathology, and social cognition. Unsworth et al. (Chapter 2) demonstrate the broad view on working memory capacity, its role as a strong predictor of intelligence level and other higher order cognition, and its role in various real-world phenomena such as aging, stress, prejudice, and even alcohol consumption. On the other hand, von Hecker et al. (Chapter 14) crossed the traditional borders among cognitive disciplines and presented the research on the generative reasoning as influenced by depression, aging, stereotype threat, and prejudice.

When one compares the content of the chapters in this book, considerable support is given for the argument that such interdisciplinary attempts substantially add to the understanding of the issues in both literatures. We think that the most beneficial way to read this volume is to compare research strategies across different domains. Subsequently, we offer several examples of such possible broader views across different literatures.

As one example, considerable knowledge about attention processes might be achieved by analyzing the concept of executive attention (Unsworth et al., Chapter 2), comparing that with the role of attention in the studies on aging of cognitive control (West & Bowry, Chapter 5; Verhaeghen, Cerella, Bopp, & Basak, Chapter 7), and then comparing that with studies on the role of attention processes in cognitive psychopathology (attentional bias in anxiety, Fox & Georgiou, Chapter 10; context processing in schizophrenia, Barch & Braver, Chapter 6). As another example, understanding the basic research on working memory and its applications can be achieved by first reading a general overview from the perspective of cognitive psychology (Unsworth et al., Chapter 2), by next reading perspectives based on cognitive aging (Oberauer, Chapter 3), and then by reading cognitive psychopathology perspectives (Sliwinsky, Smyth, Stawski, & Wasylyshyn, Chapter 4; Waltz, Chapter 13). For yet another example, the best way to understand the research frontiers in inhibition processes may be to study chapters about inhibitory control in general cognitive psychology (Unsworth, et al., Chapter 2), then to compare that with chapters about aging of inhibitory processes (Oberauer, Chapter 3; Verhaeghen, Cerella, Bopp, & Basak, Chapter 7; Maylor, Schlaghecken, & Watson, Chapter 12), and finally to compare those with chapters about psychopathology of inhibitory processes (McIntosh, Sedek, Fojas, Brzezicka-Rotkiewicz, & Kofta, Chapter 9; Joormann, Chapter 11).

Our final general example, indicating a *signum temporis* of modern technological advances, emphasizes that neuroimaging paradigms described in several chapters of our volume are important for understanding the mind/brain mechanisms of aging (West & Bowry, Chapter 5) and different forms of psychopathology (schizophrenia, Barch & Braver, Chapter 6; Alzheimer's disease, Waltz, Chapter 13).

One barrier to reading and integrating research outside one's own area of expertise is a lack of familiarity with paradigms common in research on other topics. An important goal of this volume is to facilitate cross-area research by familiarizing researchers with paradigms and findings in other areas. Thus, subsequently we present a brief tutorial on the basic research paradigms described in the book. Understanding those paradigms is crucial for understanding the questions addressed in the chapters, how the questions were addressed, and how the findings answer those questions. In that sense, the present volume offers an impressive collection of experimental tools for new research. For example, the researchers in the domain of emotional disorders might easily construct emotionally valenced versions of the cognitive procedures, as was done in the case of classical and emotional Stroop task, and as evidenced here in a chapter using an emotional version of negative priming (Joormann, Chapter 11) and an emotional version of a modified version of Oberauer's task (McIntosh, et al., Chapter 9). Understanding the theoretical and empirical nature of cognitive paradigms can also facilitate the applications of such tasks (e.g., spans of working memory capacity; see Unsworth, et al., Chapter 2 and Sliwinsky et al., Chapter 4) as mediators or moderators of real-life phenomena such as stereotypes, stress, or alcohol consumption.

A BRIEF TUTORIAL TO RESEARCH PARADIGMS

In this tutorial we describe the basic elements of the research paradigms. The chapters in parentheses are those that made use of the paradigms. In each description, we provide a reference to the paradigm, often a classic reference or a reference to a recent review of findings using the paradigm, and a concrete example of how the paradigm would be used. Our goal is to give the reader a basic understanding of the methods this distinguished group of researchers used to make inferences about mental functions and the limitations affecting those functions.

1. Stroop and Emotional Stroop (Unsworth et al., Chapter 2; West & Bowry, Chapter 6; Barch & Braver, Chapter 7; Fox & Georgiou, Chapter 10)
2. Span Tasks of Working Memory: Reading Span, Operation Span, and Counting Span (Unsworth et al., Chapter 2; Sliwinski et al., Chapter 4; von Hecker, et al., Chapter 14)
3. Task Set Switching (Oberauer, Chapter 3; Verhaeghen et al., Chapter 7)
4. Keep Track (Sliwinski et al., Chapter 4; Verhaeghen et al., Chapter 7; Li et al., Chapter 8)
5. Go–No Go Task (Verhaeghen et al., Chapter 7; West & Bowry, Chapter 6)
6. Negative Priming (Oberauer, Chapter 3; Maylor et al., Chapter 10; Joormann, Chapter 11)
7. N-back Task (Sliwinski et al., Chapter 4; Barch & Braver, Chapter 6; Verhaeghen et al., Chapter 7)
8. Dot-probe Task (Fox & Georgiou, Chapter 10; Joormann, Chapter 11)
9. Directed Forgetting (Oberauer, Chapter 3; Maylor et al., Chapter 10; Joormann, Chapter 11)
10. Flanker Task (West & Bowry, Chapter 5; Barch & Braver, Chapter 6; Fox & Georgiou, Chapter 10)
11. Linear Order Problems (Waltz, Chapter 13; von Hecker et al., Chapter 14)

For each research paradigm, we include a good reference to a classic use of this paradigm, a concrete example to walk the reader through, and some notes on the consensus of interpretation and/or debates about what inferences can be drawn. Thus, the reader will know where each given research paradigm came from, what is commonly made of it, and sources for getting more detail.

Stroop and Emotional Stroop

The Stroop task has been an important part of the psychologists tool chest for much of the past century but particularly so over the past 20 years. The reader is referred to a review by Colin M. MacLeod (1991) for a survey of important variables for this task, findings, and theoretical explanations. A more recent review of findings from studies using the emotional Stroop is by Williams, Mathews, and Colin MacLeod (1996). (The two MacLeods are different people, one from Canada and one from Australia.)

The Stroop task is performed in several different ways. One common technique is to do the task pretty much the same way John Ridley Stroop did it for his dissertation in 1935. Namely, words that reflect color names are printed in an ink that is incompatible with the word. The subject is to name the color of the ink in which the word is printed. Different control conditions are used but a common one is to also have the subject name the ink color in which nonsense words or strings of random letters are printed. A large number of the incompatible words are printed on one sheet and control items on another sheet. The dependent variable is the time to name the ink color of each item on the sheet. This technique is often used in clinical or group settings. The technique used more commonly in laboratory settings is to present a single color word or control item, typically on a computer screen, and to measure time to indicate the ink color of that item by key press or vocal response. The common finding with both techniques is that it takes longer to name the ink color if it is in the form of an incompatible color name (e.g., the word RED printed in green ink) than if it is in the form of a neutral word or random letters. It is more difficult to manipulate the nature of the Stroop task in the "sheet of items" procedure than in the "item at a time" technique. One such important technique is the presentation of compatible words such as RED printed in the color red intermixed with the incompatible words. The critical dependent variable remains the time to name the color of ink for incompatible words but the interference effect is generally larger and more robust when some of the items are color names compatible with the color of the ink. This manipulation appears to give a more reliable and robust group difference than the "sheet of items" approach or the "item at a time" technique with only incompatible items.

The emotional Stroop task also involves presenting words in various colors and having the subject name the color of the ink. However, the words in the experimental condition are not incompatible color words but words with emotional connotation (MacLeod, 1991). The assumption is that words associated with a particular psychopathology will cause more interference for a subject suffering from that psychopathology than for a control subject. Recently, there has been active debate of whether emotional Stroop and classical Stroop task capture similar cognitive phenomena (Algom, Chajut, & Lev, 2004).

Span Tasks of Working Memory

The most popular span tasks in the cognitive literature are reading span, operation span, and counting span.

Reading Span

The Reading span or Rspan was the complex working memory task used in the Daneman and Carpenter (1980, 1983) papers that started the search for the impact and nature of individual differences in working memory capacity. Many variants of the task have been used over the years, and we discuss those later. In the original version, subjects see a series of sentences and read each one aloud. Each succeeding sentence occurs immediately after the last word of the previous sentence has been vocalized. After a variable number of sentences, the subject sees a cue to recall and tries to recall the last word of each sentence, generally in the order in which they occurred. It is common, after recall is completed, to then ask the subject a question about one of the sentences to ensure that comprehension occurred. Another feature of the original version is that the number of sentences presented before recall increases from two to five or six, consecutively.

A variety of scoring procedures have been used with complex WMC tasks. Daneman and Carpenter (1980) used a strict span scoring procedure in which subjects received a single number for the task: the highest sentence set size recalled perfectly on two out of three presentations. This scoring method has some undesirable psychometric properties, however. First, it leads to rather severe restriction of range and reduced reliability. Second, the distributions of such scores are generally not normal. This method of scoring fits with the notion from Miller (1956) of the limit on immediate memory being based on some number of slots or bins, namely 7 ± 2.

Because Rspan and all the other complex WMC measures are typically used to study individual differences, such psychometric problems can be important. This is particularly true when a researcher would like to accept the null hypothesis about group differences and to have that nondifference be meaningful. The problems have been dealt with in several ways (Turner and Engle, 1989). The Engle lab compared a variety of scoring techniques and settled on what is called the absolute span. The score consists of the sum of the number of individual words from all perfectly recalled sets. Thus, if a subject recalls all the words from one set of five sentences and one set of six sentences, those contribute to the absolute span score. This method provides a much wider range of scores than does the Daneman & Carpenter span technique, and the reliability is better.[1]

Another feature of the Rspan task that has changed from the original version is the order of set size. Daneman and Carpenter started with three sets of two sentences each and progressively increased the set size to five or six. This assumes that each subject encodes and rehearses each sentence

[1] The reader should consult a paper by Conway, et al. (in press) for a full discussion of scoring such tasks and recommendations for a new and different scoring procedure.

equally, but another possibility is that there are individual differences in the effect of progressively larger set sizes that have little or nothing to do with differences in WMC. Cantor, Engle, and Hamilton (1991) initiated the idea of presenting the set sizes randomly so that subjects would be unable to predict the length of a set. Another innovation is to use unrelated items printed after the end of the sentence as the recall items. This allows much greater control over the nature of the items, and unrelated words, digits, and letters all have been successfully used. This precludes the possibility that the person does not actually recall the sentence-final word but reconstructs it from memory of the rest of the sentence. Kane et al. (2004), for example, used individual letters following each sentence. The correlations with other complex WMC tasks and with criterion tasks such as reading comprehension and Raven do not seem to depend on the specific form of Rspan.

Operation Span

The Operation span or Ospan was first used by Turner and Engle (1986) to test the notion that the correlation between Rspan and reading comprehension was simply a result of the Rspan being a proxy for reading comprehension. If that were true, then the operation span should not predict reading comprehension. However, in fact, Ospan predicted reading comprehension at least as well as Rspan, and the two tasks account for considerable common variance in higher order tasks regardless of whether those tasks are verbal or spatial (Kane et al., 2004). The Engle lab has performed Ospan in a variety of ways and with a variety of to-be-remembered items. The most common version is to present the subject with a sentence including an arithmetic string such as “Is $6/3 + 2 = 7$? show” The subjects must respond yes or no, generally orally, as to whether the equation is correct and attempt to commit the word to memory. The tester then presses a key on the computer keyboard to progress to the item to be recalled. After some random number of operation–word strings, the subject sees a cue to recall such as ??? and tries to recall the words in the correct order (La Pointe & Engle, 1990). As with Rspan, the specific form of the operation span or the nature of the items to be recalled does not seem to materially affect the relationship with other WMC tasks or with criterion tasks (Engle, Tuholski, Laughlin, & Conway, 1999; Kane et al., 2004). The Engle lab recently developed an automated version of Ospan that can be administered with little or no supervision by the tester. That version is written in and therefore requires Eprime (Schneider, Eschman, & Zuccolotto, 2002) for administration. The program initially tests the time each subject requires to perform a series of arithmetic operations without a requirement to recall anything. That time per arithmetic string is passed through to the next stage of the program, which administers Ospan with the presentation time of the arithmetic string adjusted for that particular subject. The to-be-remembered items are letters, and recall is made with a

Cambridge University Press
978-0-521-54195-4 - Cognitive Limitations in Aging and Psychopathology
Edited by Randall W. Engle, Grzegorz Sedek, Ulrich von Hecker and Daniel N. Mcintosh
Excerpt
More information

mouse and button presses. This task has acceptable reliability and stability as indicated by alpha scores and by test–retest and has acceptable validity as indicated by the relationship with Raven and other WMC tasks. It can be downloaded from http://psychology.gatech.edu/renglelab/.

Counting Span

This task, also called Cspan, was developed by Robbie Case and his colleagues (Case, Kurland, & Goldberg, 1982) to study the neo-Piagetian concept of M-space in children and was first used as a WMC task by Baddeley, Logie, & Nimmo-Smith (1985). Case et al. showed children a series of pictures of circles that were two different colors, and each child counted the circles of a given color. After a series of such pictures, the child was to recall the digit string corresponding to the sums of the counted circles. Thus, the task is functionally a digit span task interleaved with counting. Engle et al. (1999) modified Cspan to require more attention control to count the objects. Circles and squares were displayed with the circles being in two different colors, one the same as the squares, and subjects counted the circles in that color. After a series of such displays, they recalled the digits corresponding to the sum of the circles on each display. This task loads well on the same latent variable as Rspan and Ospan and accounts for similar variance in criterion tasks such as Raven (Engle et al., 1999; Kane et al., 2004). One advantage of this task is that difficulty is easily manipulated via similarity of color of the objects and number of objects to be counted and distractors. Thus, the task is a good one for studies comparing different ages and developmental levels.

Task Set Switching

A wide variety of tasks are used to study task set switching, and we will only speak of them generally here. The seminal paper on such tasks appears to be Jersild (1927) but most modern literature can be traced back to studies by Allport, Styles, and Hsieh (1994) and Rogers and Monsell (1995). A prototypical task presents subjects with a string of symbols or events, and two or more different operations can be performed on the string. For example, a string of numbers may be shown to subjects, and they either add two to a number or subtract one. Which operation must be performed either is cued in some way such as the color of the number or a given operation is performed on some number of trials in a row before switching to the other operation for the same number of trials. Thus, subjects may add two to each number for three trials and then subtract one from each number for three trials. The cost of making a task switch can be calculated by comparing the time to perform an operation on a trial following a switch with the time to perform that operation in a block of pure trials in which only that operation is performed. This type of switch cost is called a local switch cost. If the time to do an operation on trials later than the first in that run (e.g., trials 2 and 3 in the run) is compared with time to do the operation in blocks of pure trials, a global switching cost can be calculated.

Keep Track

This task, first described by Garavan (1998), is similar to task set switching paradigms but running counts of events must be maintained. For instance, subjects may be shown a long sequence of circles and triangles and must keep track of the number of each since the last query. Because subjects press a key to present each object, we can measure the time to increase the counter of a circle if it follows in another circle compared to the time to increase the counter if the circle follows a triangle. Generally, the time to increase the counter is faster if the circle follows another circle than if it follows a triangle. Thus, there is the equivalent of a task switch cost, which Garavan (1998) attributed to shifting information in the focus of attention.

Go–No Go Task

This represents a response mode more than a particular task (e.g., Bates, Kiehl, Laurens, & Liddle 2002 and Logan 1994). In other words, a Go–No Go procedure could be used with nearly any cognitive task. Subjects are to make a response to some events and to withhold the response to other events. A common procedure is to present a string of two different letters (e.g., X and K) with one of the letters occurring much more frequently than does the other (e.g., p(X) = .8, p(K) = .2). In this case, the subject is to press a key as soon as possible when the X occurs but to do nothing when the K occurs. Critical comparisons across groups are the number of false alarms (i.e., making a response to a K) and the reaction time when a target (X) follows a distractor (K). This task is often used to study the ability to inhibit making a prepotent or predisposed response.

Negative Priming

The term negative priming is often used as both a procedure and a phenomenon. For example, Tipper (1985) showed that a stimulus that has to be explicitly ignored as a distractor in one trial, a so-called *prime trial*, leads to slowed responding when it becomes a target in an immediately succeeding *probe trial*. In a typical procedure, pairs of partly superimposed letters of two different colours are presented, and participants are to name the letter that is presented in one of the colours, e.g., red, as quickly as possible. For example, the target in the prime trial may be a red "r," partly superimposed by a green "t." In the immediately succeeding probe trial, the red target is now a "t," superimposed by a different distractor, e.g., a green "d." The typical finding is that the subject is slower to name the "t" when it was presented as a distractor on the prime trial. In the classic version, a series of prime–probe trial sequences is presented as a column of letter pairs on a page, and reading time is taken for the page as a whole. In more recent computer-based versions, prime–probe trial sequences are presented individually on a screen, and response times are measured for those individual trials. Reading times of the prime versus probe trial in sequences of the described type are compared with the reading times from a series of control-trial sequences, which are designed such that, in the prime and probe trials, all four letters involved are different from each other. That is, in the control condition, there is no identity overlap between prime trial distractor and probe trial target. One widely discussed explanation for the negative priming effect is that as a to-be-ignored distractor, a letter is actively inhibited, and thus, either its activation in working memory is dampened, or its activation is decoupled from potential response effectors (May, Kane, & Hasher, 1995). The negative priming effect extends to situations in which to-be-ignored distractors and subsequent targets are not identical, but only related (Williams, Watts, MacLeod, & Mathews, 1997). Experiments have shown that the amount of negative priming (which is indicative of the assumed amount of active inhibition) diminishes as mental workload increases and that there is less negative priming observed in participants low (vs. high) in working memory capacity, as measured with the operation-word span task (Conway, Tuholski, Shisler, & Engle, 1999).

N-back Task

This task has become quite popular because it lends itself to use in fMRI studies of working memory, even though we know relatively little about the experimental psychology of the task (Awh et al., 1996; Cohen et al., 1997; Smith & Jonides, 1997). Subjects are presented a string of events (e.g., letters, words, or pictures) and make a response as to whether the event is identical to the Nth item back. Thus, in a 2-back task, the response indicates whether the current event is identical to what was presented two items ago. Working memory demands of the task can be manipulated by varying N, and the specific component of the working memory system used for the task can be manipulated by varying the nature of the to-be-remembered events. Letters are likely to lead to use of speech-based–mechanisms and pictures more likely to require visual–spatial mechanisms.