53

Stage theories refuted

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This chapter examines the stages of processing meta-theory (SPM) that has guided construction of theories in psychology during the past 350 years. from philosopher René Descartes in seventeenth-century France to neuropsychologists Carl Wernicke and Paul Broca in nineteenth-century Europe to psychologists Dominic Massaro and Alan Baddeley in late twentieth-century America and Britain. The most basic SPM assumptions are that processing and storage of information take place within a finite number of autonomous modules or stages. and that some stages are sequentially ordered with respect to others. Flowcharts typically summarize these assumptions. as in figure 53.1. The traditional stages of processing for verbal information are comprehension. storage. retrieval. and production. SPM flowcharts can add new stages and can alter old labels to represent new types of information processing. but whatever the labels. the stages must be finite in number. distinct. independent. and sequentially ordered between input and output. For example. the storage stage in figure 53.1 begins only after comprehension is complete. and production begins only after storage and retrieval are complete.

To illustrate SPM in a recent manifestation. I will describe a 1993 theory of memory and some of its seemingly minor crises related to its SPM assumptions. I then review a range of findings that directly contradict SPM and suggest a new shape for future theories in psychology.

Minor crises in current theories of memory

The minor crises concern relations between memory for lists and memory for sentences. By postulating two autonomous systems for processing and storing lists versus sentences. current multi-store theories of memory illustrate the SPM assumption that information processing and storage take place within autonomous modules. or stages. For example. Alan Baddeley. a leading British researcher investigating the psychology of memory. postulates a memory system known as the "phonological loop." which processes and stores word lists in *raw* phonological form for short periods of time and is separate and distinct from the system for processing and storing the syntax and meaning of sentences (the central executive).

Baddeley's multi-store account of memory currently faces two sorts of empirical crises. The first concerns cases where sentence variables influence list processing in ways that would not be expected if fundamentally autonomous memory systems process sentences versus lists. By way of illustration. consider a recently discovered effect in my lab whereby syntactic and semantic factors influenced immediate recall of words in rapidly presented lists. I and my colleague Lise Abrams (1996) compared immediate memory for identical words in *chunked* versus *unchunked* lists that were six to eight
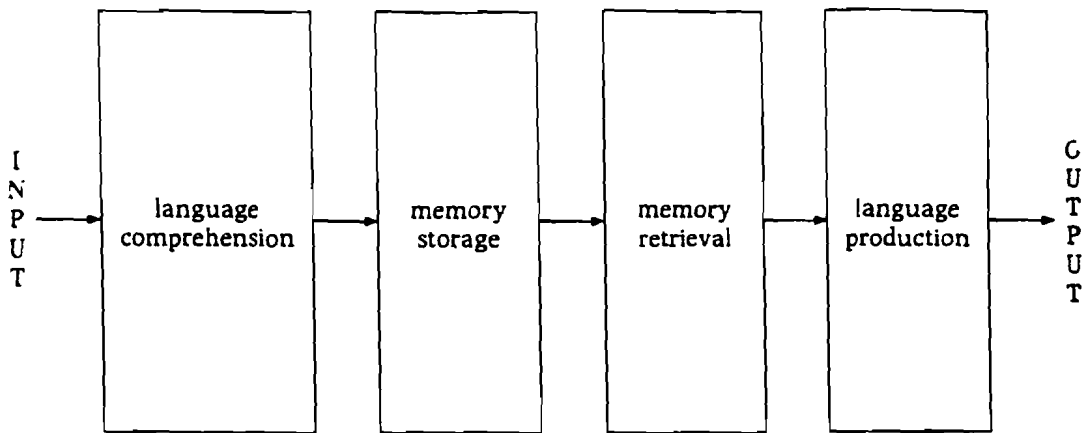
Figure 53.1 A standard stages of processing flowchart illustrating the stages for comprehending, storing, retrieving, and producing verbal materials.

words long and rapidly presented via computer so as to preclude rehearsal. Chunked lists, such as 1 (below), contained two familiar two-word phrases located at unpredictable positions in the strings, whereas unchunked lists, such as 2 (below), were identical except for the substitution of two unrelated words that destroyed the phrases. Results of this experiment showed that words in unchunked lists were more poorly recalled than identical words in the phrases of chunked lists. For example, *night* was recalled more poorly as an unrelated word in list 2 than in the phrase *night gown* in list 1, but the unrelated word *mind* was recalled equally poorly in both lists. Because phrases are fundamentally syntactic/semantic entities, these findings indicate that sentential factors (syntax/semantics) influence short-term memory within rapidly presented lists. To explain this result and meet this first crisis in general, multi-store theories must explain how semantic/syntactic factors influence a supposedly separate store traditionally viewed as purely phonological in nature.

1 Chunked list: phrase *good faith* mind *night gown* film (phrases italicized).
2 Unchunked list: phrase people faith mind night hose film (unrelated words).

The second crisis concerns phenomena in immediate recall of *sentences* that are attributable to factors that characterize lists. For example, my colleague Michelle Miller and I showed that a certain aspect of lists – namely, listlike prosody – when introduced into spoken sentences causes a short-term memory phenomenon (known as repetition deafness) that is otherwise observed only within lists. To explain this result and meet this crisis in general, multi-store theories must explain how a phenomenon can arise in the supposedly autonomous memory system for storing and processing sentences by introducing a characteristic of lists.

Problems with SPM

As the above crises illustrate, the problem with theories derived from SPM is not just the widely acknowledged crudeness or vagueness of SPM diagrams currently used to describe psychological findings. Rather, the widely unacknowledged problem is that

available data directly contradict SPM assumptions. To make this point more generally and in greater detail. I next examine the traditional SPM stages in pairs, beginning with comprehension versus memory (i.e.. storage and retrieval in figure 53.1), and review the original data favoring the hypothesis that textbook-title categories such as memory and comprehension constitute separate and sequentially ordered processing stages in the brain. I then show how more recent data have undermined both the original data and the basic SPM assumptions themselves. I conclude by showing why theories derived from SPM are also unlikely to support sophisticated applications of psychological knowledge.

Are comprehension and memory dissociable stages?

Nineteenth-century neuropsychological data suggested that comprehension and MEMORY are dissociable processes, such that comprehension disorders (e.g.. Wernicke's aphasia) can occur without concomitant memory disorders (e.g.. anterograde amnesia). and vice versa. However. neuropsychology moves on. More recent studies using highly sensitive implicit measures of on-line comprehension and memory have called this dissociation into question. The findings of Loraine Tyler. a neuropsychologist at Birkbeck College. London. illustrate some of these newer data. Tyler (1992) directly addressed the separability of comprehension and memory as distinct, sequentially ordered stages by testing whether the so-called comprehension deficit of Wernicke's aphasics is truly specific to comprehension or reflects both a comprehension deficit and a memory deficit that shows up only when tested via after-the-fact, explicit measures based on conscious judgments about prior comprehension (see Article 29, DEFICITS AND PATHOLOGIES).

Tyler's first step was the traditional demonstration that Wernicke's aphasics fail to respond accurately to questions such as "Is this sentence grammatical?." unlike normal controls presented with the same sentences. This frequently reported finding indicates that Wernicke's aphasics have a comprehension problem. or a memory problem. or both. when tested after the fact via explicit measures. Tyler's next step was to present similar sentences to her aphasics in an on-line priming task. where effects of ungrammaticality could be determined via indirect measures at the time of processing. These new data showed that her Wernicke's aphasics responded like normal controls. as if their comprehension deficit were indistinguishable from a memory deficit that can be overcome via tests that do not require conscious retrieval after on-line processing has occurred. This second finding undermines the first and most fundamental source of support for SPM and suggests that memory and comprehension may not be separate processing stages after all.

Tyler's experiments illustrate two widely used means of testing memory. known as direct and indirect tests. The latter show the effects of previously presenting a word (usually in an incidental context earlier in the experiment) on subsequent word perception (e.g.. reduced recognition time) or on subsequent word production (e.g.. reduced time to produce or name the word). without requiring conscious recollection of the prior experience with the word. By contrast. direct tests call for conscious recollection of the prior experience with the word(s) – for example, via cued recall. explicit recognition. or free recall of the previously presented word list. Within this larger context. Tyler's results comport with results from a wide range of direct and indirect tests of comprehension and memory in normal people. suggesting that identical mechanisms

underlie everyday language comprehension on the one hand and the encoding and storage of verbal materials in laboratory studies of memory on the other.

The existence of identical mechanisms for comprehension, encoding, and storage of verbal information explains why nobody has ever been able to establish a detailed, convincing dividing line between where language comprehension leaves off and where storage begins, either empirically or theoretically, for either everyday behavior or experimental tasks. No such dividing lines can be established, because no memory-specific verbal processes exist independently of mechanisms that have evolved for learning, comprehending, and producing language.

Are memory retrieval and production dissociable stages?

Is memory retrieval (e.g., the process of retrieving words in verbal memory studies) distinct and separate from the everyday ability to produce words in sentences? No data directly support this basic SPM assumption, and considerable data contradict it. For example, data from the tip-of-the-tongue (TOT) phenomenon indicate that everyday language-production processes can be indistinguishable from word retrieval in verbal memory studies. TOTs normally occur when a speaker is unable to retrieve a familiar word such as *locust* or *Napoleon* during everyday speech production, even though they can often retrieve aspects of the word (e.g., its first letter, how many syllables it contains, its stress pattern, and other words similar in sound or meaning or both). Information about TOTs has come from three sources: diaries recorded at TOT onset during everyday speech production, questionnaires that assess a person's history of TOTs, and laboratory TOTs in response to questions such as "What do you call the leather band formerly used for sharpening an old-fashioned razor?" Interestingly, conclusions from all three sources of TOT data are indistinguishable, indicating that identical mechanisms underlie everyday speech production and memory retrieval in laboratory tasks.

Lise Abrams and I recently reviewed a wide range of other data that indicate not just close parallels, but identity between processes underlying everyday language production and laboratory word-retrieval tasks (see Article 14, LANGUAGE PROCESSING). For example, the time required to begin pronouncing a visually presented word is reduced if participants have previously encountered the same word in an incidental auditory context, and these response times are strongly correlated with cued recall of the corresponding word as having occurred earlier in the experiment. In short, pronunciation onset time indirectly measures memory for prior occurrence of the word and the ability to explicitly retrieve the word, but at the same time reflects a word *production* process. These and other results thus indicate that identical mechanisms are used for language production on the one hand and retrieval of verbal materials in laboratory studies of memory on the other. Moreover, far from being separate processing stages, memory-retrieval mechanisms and language-production mechanisms are unitary and inseparable, even though different types of tasks can tap into these unitary language abilities in different ways.

Are comprehension and production dissociable stages?

Comprehension and production are the most widely separated stages in SPM, occupying opposite ends of the processing spectrum in figure 53.1. They are also the oldest stages, first postulated by René Descartes in 1637, and were the first to receive empirical

'port. in work of Carl Wernicke published in 1874. Wernicke argued that compre-
ısion and production constitute separate processing stages. because comprehension
ᴜrders in Wernicke's aphasics can occur without the concomitant production dis-
lers seen in Broca's aphasics, and vice versa. However. more recent studies, using a
riety of new and highly sophisticated techniques. suggest that aphasias are more
nplicated than was originally thought. With appropriate controls for lesion size, as
ll as for pragmatic (nonlanguage) aids to comprehension. Wernicke's and Broca's
hasics exhibit both receptive and expressive deficits that tend to be commensurate in
ture and in extent. Moreover, microelectrode techniques have shown that stimulat-
; one and the same cortical site can affect both production *and* perception of corre-
ınding phonological units. suggesting that production and perception are inseparable
a neural level. Moreover, even more recent neuroimaging data support a similar
ıclusion (see Article 32. NEUROIMAGING).

·urther support for common components underlying perception and production
nes from a wide range of data from normal adults, including parallel empirical effects
ɔroduction and perception, interactions between processes for production and those
 perception, the nature of units for production and perception, the nature of errors
 perception versus production, top-down effects in perception, bottom-up effects in
ıduction, effects of concurrent production on a perceptual illusion known as the
:rbal transformation effect." and indirect tests of language perception and memory.
ıwing, for example, reduced time to begin pronouncing a visually presented word
 ᵊ to prior auditory perception of the same word in an incidental context earlier in an
ıeriment. In short, many different sorts of data indicate that perception and produc-
ı cannot represent separate, independent stages of processing: and these include
· original neurological data once thought to support their separation.

'M and applications of psychological knowledge

:e possible reaction to the empirical difficulties facing SPM is: "So what? Who
:es about theory anyway? Isn't psychology primarily interested in experiments and
ıctical applications. and haven't SPM flowcharts inspired lots of experiments over
· past century?" Perhaps: but SPM experiments may have limited applicability. The
ıblem can be illustrated via a *Gedanken* experiment involving a 400-year time warp:
·cifically. a test of the hypothesis that seventeenth-century physicists should adopt
SPM approach to ballistics that resembles twentieth-century SPM psychology.
this *Gedanken* hypothesis. seventeenth-century physicists should analyze ballistics
o a sequence of ordered stages. beginning with construction of the projectile and
ınching device (input), through impact of the launched projectile (output). A typical
·vchart in SPM ballistics might resemble figure 53.2a. Stage 1 (orientation) positions
: gun relative to the earth. Stage 2 (ignition) inserts the projectile into the gun and
:s it. Stage 3 (ascent) projects the missile to some determinable height (seventeenth-
ıtury physics has twentieth-century technology in this time warp) before it starts to
ınge (stage 4. descent) and finally impact the earth (output).

With refined *observation* of these stages. one can imagine that SPM physicists might
:ntually be able to describe something like the actual path of a projectile. and to
·dict the path of identical projectiles fired under identical conditions. The problem is
ıt SPM ballistics can describe only particular trajectories for particular projectiles

a:

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I N P U T  →  orientation stage  →  ignition stage  →  ascent stage  →  descent stage  →  OUTPUT IMPACT
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b:

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I N P U T  →  flow  →  high tide  →  ebb  →  low tide  →  OUTPUT
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| 0 | Time | 12 hrs |

| min. | max. | min. |

Depth of processing
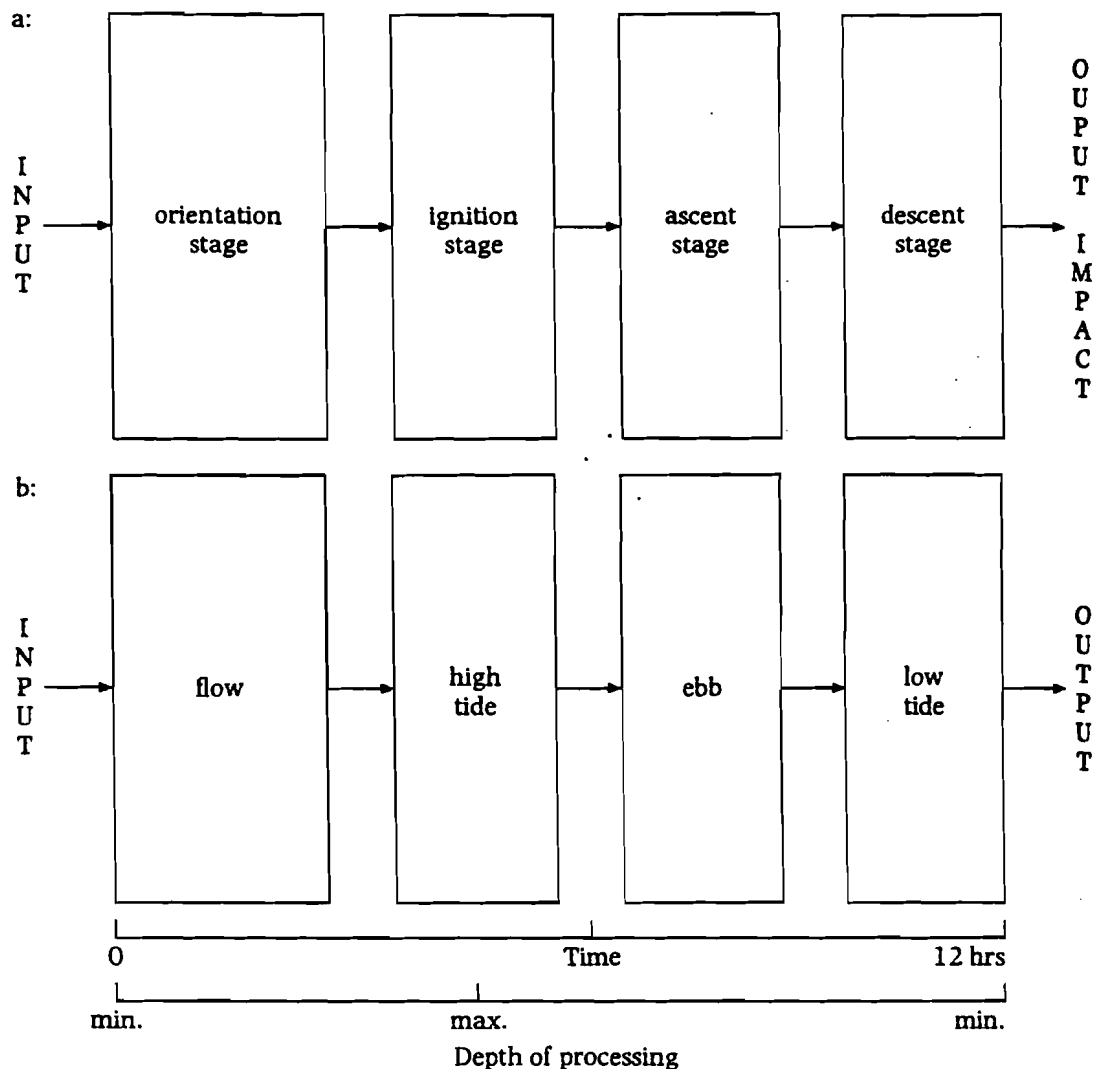
Figure 53.2   a: Hypothetical stages of processing in seventeenth-century information processing ballistics. b: Hypothetical stages of processing in sixteenth-century information processing oceanography.

fired under particular conditions, an achievement of dubious practical value, because launching a series of identical projectiles under identical conditions is not a reasonable goal. As a fundamentally descriptive approach, SPM can *in principle* provide no way of developing the explanatory or theoretical concepts that are needed for general applications in either physics or psychology. That is, predicting paths of different projectiles fired under variable (real-world) conditions requires theoretical concepts such as mass, gravitational force, inertia, kinetic energy, and centrifugal force that are unattainable within a descriptive approach such as SPM. In short, SPM would have constrained practical as well as theoretical developments in physics, just as in psychology.

This is not to say that SPM is incompatible with *all* possible applications. A *Gedanken* experiment with a 500-year time warp nicely illustrates this point. Hypothetical SPM

.eanographers in sixteenth-century Europe might have developed flowcharts resem-
.ing figure 53.2b for predicting tide levels as a function of time in various European
.irbors. Stage 1 (flow) describes the water flow up to stage 2 (high tide). and stage 3
.bb) describes the water flow down to stage 4 (low tide). These stages can be meas-
·red via *response times* and via *depth of processing* (i.e.. water depth) at points of inter-
.t in the harbor. Clearly. *these* descriptive measurements do have *some* (restricted)
ractical value. Although general theoretical principles governing tidal phenomena
:ave been understood for over a century. the details needed to apply these principles
) particular harbors are so variable. so many. and so complex that pre-theoretical or
escription-based predictions are sometimes as effective for negotiating a particular
iarbor as more sophisticated. theory-based predictions employing the fastest state-of-
he-art computers.

   Nonetheless. pursuing SPM oceanography for an indefinite period of time will never
ive rise to explanatory or theoretical concepts such as mass. force. gravitational attrac-
.on between astronomical masses. centripetal acceleration. and friction. concepts that ·
re needed to accurately predict tides *of any sort* – for example. *atmospheric tides, earth
·des.* and *lunar tides* – *anywhere* in the universe. As a descriptive meta-theory. SPM
recludes applications that are sophisticated and general.

Conclusions

his chapter has presented both empirical and meta-theoretical arguments against
·PM. The meta-theoretical arguments focused on practical limitations of SPM as a
:escriptive meta-theory. The empirical arguments focused on evidence violating SPM
issumptions – for example. evidence that lists and sentences are processed within the
·ame memory system. and that neither storage and comprehension. nor memory re-
rieval and production. nor comprehension and production can be considered inde-
)endent. sequentially ordered stages.

   However. meta-theoretical dreams die hard. SPM theorists might hope that if tradi-
:ional stages don't work. then perhaps other. more complex stages might work. Such
iopes fly in the face of both experience and logic. More recent flowcharts have intro-
!uced labels such as "attention." "encoding." "recognition." and "identification." which
ack precise and meaningful definition. and have further concealed our ignorance
.vithin a purely descriptive SPM framework rather than promote insight into under-
ying mechanisms.

   What is needed instead is a clear. viable alternative to SPM that is explanatory or
heoretical in nature. and over the past decade. the general shape of this new alterna-
ive has become increasingly clear. Common units and processes underlie perception.
nemory. and production of language. rather than separate units in separate process-
ng modules that store lists versus sentences. or language comprehended versus pro-
!uced versus learned. Support for this new view comes from a wide range of findings.
ncluding evolutionary analyses indicating that memory and production of language
:nust have developed together. rather than separately. during human evolution. A set
)f mutations that enabled some humans to speak would improve their chances of
·urvival only if they and others could understand. remember. and repeatedly use the
·ame language code. And whatever abilities evolved to comprehend. store. and produce

words in everyday life over the last million years must surely provide the basis for encoding, storing, and recalling words in twentieth-century experiments on verbal memory.

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