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SPAN Theory is not Span Theory: A brief note

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Abstract

SPAN theory (Byrne, 1998) is a theory in the cognitive, working memory tradition. *Span theory* (e.g. Bachelder & Denny, 1977a, 1977b) is a theory in the S-R behavioral tradition. Both attempt to explain similar behavioral phenomena, but they operate at different levels of analysis. SPAN theory attempts to explain declines in working memory in terms of a general slowing of cognitive processing. Span theory would assess that decline in terms of a decline in psychometric *span ability* then explore the implications of that reduced span ability for performance in a wide range of other tasks.

SPAN Theory is not Span Theory: A brief note

A recent title in *Psychology and Aging* (Byrne, 1998) seems to refer to *span theory*, a theory of intelligence and span phenomena first published in the '70s (Bachelder, 1970/1971; Bachelder, 1977; Bachelder & Denny, 1977a; Bachelder & Denny, 1977b; Denny, 1980; Denny & Davis, 1982). In fact, Byrne's paper is not about span theory at all. It is about a new theory with essentially the same name, *SPAN theory*. My purposes here are to alert the reader to the two different theories and to try to minimize confusion.

The *SPAN* of Byrne's *SPAN* theory is an acronym from the terms, Speed, Parallelism, Activation, and Noise (Byrne, 1998, p. 310). *SPAN* theory is a theory in the cognitive, working memory tradition. *SPAN* theory attempts to explain the age-related decline in working memory in terms of a decline in speed of mental processing.

Span theory is about span phenomena and their close empirical link with measured intelligence and individual differences in diverse tasks. The *spans* of span theory are approximately the same as the three *magical numbers* made famous by George A. Miller (1956). Those spans are a) the span of immediate memory, long used as a subtest on tests of intelligence; b) the span of apprehension which measures the ability to subitize, a fundamental aspect of numerical cognition; and c) the span of absolute judgment, now often called absolute identification.

Span theory derives from the S-R behavioral tradition (the Hull-Spence-Denny branch). Span theory applies broadly to diverse tasks, traditionally categorized separately under various terms, including: language expression, language reception, intelligence, short-term memory, working memory, judgment, subitizing, numerical cognition, discrimination learning, complex stimuli, and breadth of attention (see Bachelder &

Denny, 1977b, for an overview of these applications of span theory). As is common in behavioral approaches, span theory has no memory construct.

Span theory explains observations of behavior via mathematical equations (called *task equations*) and behavioral constructs including *span ability*, *span load*, and the *task*. The task, rather than the S-R unit, is taken as the fundamental unit of behavioral analysis. The term span load has replaced the original term, *task complexity*. The concept of span ability is more akin to the behavioral concept of stimulus control than it is to information processing concepts of working memory. Span ability is measureable via a span test (usually a test of immediate memory span). Span load is an objective quality of a specific task or group of closely related tasks (i.e., a *task family*). Span load is determined objectively through the process of *span load analysis*, a process which derives from S-R task analysis. A task equation is a mathematical equation of the form:

$$\text{Performance} = f(\text{span ability/span load, other variables}).$$

Span theory research focuses on the development and validation of task equations linking psychometric span to performance in other tasks. For example, there is a close and direct relation between psychometric span ability and language imitation and production in retarded children (Bachelder, 1978, Part 3; Bachelder, 1977; Bachelder & Denny, 1977a, pp. 240-245). In the same vein, Bachelder (1978, Part 3) developed a task equation to predict language comprehension scores from psychometric span scores. The subjects were non-verbal institutional retarded adolescents varying widely in psychometric span ability (assessed via a non-verbal span test). Language comprehension was assessed with *The Assessment of Children's Language Comprehension* (Foster, Giddan & Stark, 1972). Free recall and psychometric span ability are directly related in retarded adolescents (Bachelder & Denny, 1989). Bachelder (1978, Part 3) developed task equations which accurately predict multi-dimensional absolute judgment data with college students based on norms for span ability measures in college students. The

predicted data (Pollack & Ficks, 1954) were previously published data from different subjects in a different laboratory.

Span theory constitutes a behavioral alternative to the working-memory conceptualization of so-called cognitive tasks. It opens the door to a rigorous behavioral account of the complex phenomena of language, intelligence, judgment, memory, and numerical cognition. As is true of most behavioral approaches, span theory lends itself directly to practical application. In fact, it was developed originally to account for individual differences in basic and classroom learning among normal and retarded learners.

Span theory and SPAN theory overlap considerably in their target behavioral phenomena, but they pose different sorts of questions and frame the results in different sorts of terms. The two theories operate on different levels of analysis. SPAN theory operates at a lower, internal level, presumably close to the level of neurological structure and function. Span theory operates at a higher level, the level of the task. SPAN theory attempts to explain individual differences in working memory in terms of hypothetical internal processes. Span theory attempts to explain individual differences in any particular target task via specific task equations incorporating measured individual differences in the behavioral construct, span ability. Because of the different levels of analysis, the two theories are not necessarily inconsistent approaches and it may be difficult to pit one against the other.

Working memory is often measured with tasks which are identical to or highly similar to the memory span task used to measure span ability. Therefore, it seems likely that research will show that span ability, like working memory, declines with age. Until research indicates otherwise, I would hypothesize that the task equations which have been developed with other subject populations will be valid in an aging population. The equations, via age-related declines in span ability, predict a wide variety of problems with complex stimuli and declines in free recall learning, language imitation, language

production, multi-dimensional absolute judgment, span of apprehension, and uni-dimensional absolute judgment. Furthermore, these predicted declines would be expected to be assessable and predictable rather precisely for an individual via psychometric measures of span ability combined with specific task equations. These are all eminently researchable questions and an exciting new area for span theory research.

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Bruce L. Bachelder, psychologist in independent practice, retired in 2004.

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