The invention of n-back: An extremely brief history

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Abstract

The article by Kane, Conway, Miura, and Colflesh (2007), on the n-back as a test of working memory, began its life as a full length manuscript. It was ultimately published, however, as a short report. The following discussion of the n-back task's invention needed to be cut from the original manuscript, but we thought that others might find it useful.

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The invention of n-back: An extremely brief history

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The article by Kane, Conway, Miura, and Colflesh (2007), on the n-back as a test of working memory, began its life as a full length manuscript. It was ultimately published, however, as a short report. The following discussion of the *n*-back task's invention needed to be cut from the original manuscript, but we thought that others might find it useful.

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"*N*-back tasks are typically implemented as continuous-recognition measures that present long sequences of stimuli, such as letters or pictures. For each item in the sequence, people must judge whether it matches the one presented *n* items ago, with *n* manipulated between blocks of trials (e.g., in the sequence *A-B-A-C-D-E-C*, the second "A" would be a 2-back match, whereas the second "C" would be a 3-back match). *N*-back arguably has face validity as a WM task because subjects must continuously maintain and update a dynamic rehearsal set while also responding promptly to each item." (Kane, Conway, Miura, & Colflesh, 2007, p. 615)

The *n*-back task has a curious history, having been independently re-invented or re-popularized in several different decades, and having witnessed continuous and widespread use only subsequent to the neuroimaging boom of the 1990s. Kay (1953) appears to have invented the task in his unpublished dissertation on the effects of aging and fatigue on human performance (cited in Welford, 1958, pp. 248-251). Civilian air crew completed 0-, 1-, 2-, 3- and 4-back tasks, both before and after their flights, on apparatus consisting of a row of 12 lights with a key beneath each; following each new light in the sequence, subjects pressed the key corresponding to the one *n*-back. Accuracy dropped steeply from the 1- to 2- to 3-back tasks. Moreover, crew who were under 30 years old significantly outperformed those who were over 30, particularly on 3-back, but the fatigue that followed a flight eliminated the advantage for younger subjects by reducing only their scores and leaving older subjects' scores unaffected. Two subsequent *n*-back publications in the 1950s confirmed Kay's report of age-related deficits in *n*-back (Kirchner, 1958), and the dramatic drop in accuracy as *n* increased beyond 1 (Mackworth, 1959).

Apparently unaware of this prior research, Ross (1966a, 1966b; Moore & Ross, 1963) re-invented the *n*-back task as a variant of the recently developed "running memory" span task of short-term memory (Pollack, Johnson & Knaff, 1959). Ross's work is scarcely cited, but it provides the most thorough task analysis of *n*-back to date. It also conceived experimental manipulations of serial order that recent studies independently verified as critical to *n*-back's validity as a working memory measure (e.g., Gray et al., 2003; Kane et al., 2007; Oberauer, 2005).

After 25 years without *any* subsequent *n*-back publications, two separate studies initiated the modern era of *n*-back research. Citing Kirchner's (1958) aging work, Dobbs and Rule (1989) developed a version of *n*-back in which adults in their 30's to their 90's heard a sequence of digits and called out the corresponding 0-, 1-, or 2-back digit. This large-scale study is often discussed in the aging-of-working-memory literature, but it seems to have inspired only a few subsequent *n*-back studies with older-adult populations (Hartley, Speer, Jonides, Reuter-Lorenz, & Smith, 2001; Kwong-See & Ryan, 1995; Oberauer, 2005; Verhaeghen & Basak, 2005). At about the same time, however, Gevins et al. (1990) re-invented the task while ushering in its neuroscientific study. They analyzed event-related potentials (ERPs) from 5 test pilots performing 0- and 2-back tasks for hours at a time. Fatigue dramatically affected 2-back error rates and ERP pattern and magnitude. A widely cited follow-up study by Gevins and Cutillo (1993) demonstrated substantial frontal-lobe contributions to *n*-back and so deserves credit for stimulating an explosion of PET and fMRI studies (e.g., Awh et al., 1996; Cohen et al., 1994; Jonides et al., 1997; Schumacher et al., 1996).

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