A Review of the Evolutionary Significance and Developmental Applications of the Phonological Loop and an Appraisal of the Conceptual Model as a Tool

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ABSTRACT:

This paper seeks to investigate if there is reason to believe in the existence of the phonological loop, an element of Baddeley & Hitch's Multicomponent Working Memory Model, through findings of evolutionary significance and developmental research. The Multicomponent Model of Working Memory was first proposed in 1974 as a response to developing work on short term memory in the field of Information Processing Theory (A. D. Baddeley & Hitch, 1974). Through a review of one component of an influential theoretical model that has withstood 40 years of credible citations, this paper is also designed to appraise the usefulness of the theoretical model itself as a tool for advancements in the field of cognitive and developmental psychology. Findings: The phonological loop serves as a language learning tool (A. Baddeley et al., 1998), and the Nonword Repetition Task (NRT) is a significant testing mechanism for it, though not a pure test (Coady & Evans, 2008; Susan E. Gathercole et al., 1997). Primarily through the Nonword Repetition Task, research finds that the phonological loop has evolutionary significance in both foreign (Juffs & Harrington, 2011; E. Service, 1992; Elisabet Service & Kohonen, 1995) and native language acquisition (Chiat Shula & Roy Penny, 2007; Coady & Evans, 2008; null Gathercole, 1999; Susan E. Gathercole et al., 1997; Hoff et al., 2008; Metsala, 1999; Roy & Chiat, 2004; Stokes & Klee, 2009). A phonological loop deficit is associated with language disorders (Susan E Gathercole & Baddeley, 1990), and the Nonword Repetition Task is widely used as a standard test for dyslexia (Coady & Evans, 2008). Furthermore, the product of efforts to find studies for the phonological loop such as the Nonword Repetition Task, may be more significant to the advancements in developmental psychology than the scrutinized component of Baddeley & Hitch's model itself. As it is clear that the multicomponent model of

working memory has proven to be efficacious, and as Information Processing Theory is colloquially and facetiously known as the 'study of boxes and arrows,' I arrive at a similar sentiment to Lakatos (1968) as well as Baddeley, who quotes: "[Lakatos] rejects the idea of any theory being "true" and accepts that progressive theories may contain anomalies and hence be "false", to be replaced in due course by theories that are less false."

Understanding the Model: Baddeley & Hitch's Multicomponent Model of Working Memory:

Alan Baddeley and Graham Hitch's 1974 paper first introduced the multicomponent model of working memory as a response to initial ideas on the role of short term memory provided by researchers in the developing field of Information Processing Theory (Atkinson & Shiffrin, 1968), which likened the mind to the digital computer. This integration of philosophies of computer science and psychology was the foreground of the field of cognitive psychology that we know now. The multicomponent model of working memory is a composite framework for the temporary storage and retrieval of information for working memory. Working memory is the conscious processing of information in realtime— in other words, the part of the brain that keeps things 'in mind.' It is sectioned off into two auditory and visual buffer stores. A buffer store, opposed to an archival store, is a location where information stays for a short period of time. The auditory buffer store of the multicomponent model of working memory is the phonological loop, while the visual buffer store is called the visuospatial sketchpad. In 2000, Baddeley added the episodic buffer, which is assumed to combine information gathered across systems to create multidimensional anecdotes for working memory. The episodic buffer can organize stimulus from either of the respectively listed buffer stores of working memory, as well as information at varying degrees of retention (short term, long term, and working memory). While the mechanics

of the phonological loop have been debated extensively, for the purpose of this paper a more general discussion is sufficient. The phonological loop is further bifurcated into two subcategories, the phonological store (the inner ear) and the articulatory process (the inner voice). To understand the role of the phonological loop at an anecdotal level, researchers often detail the experience of trying to remember a phone number without having a pen and paper. While searching for the pad, it is almost inevitable that you will repeat the numbers over in your head. This is the brief store, which can remember the list of numbers, and rehearsal mechanism, which repeats the numbers until they can be written on paper.

Nonword repetition task:

A critical contribution to measuring the role of the phonological loop in language development has been the Nonword Repetition Task, which will be used repeatedly in the following studies. Consider a memory task that first provides a list of familiar words to memorize, and second requires the subject to recall the words from the list. The subjects would inevitably call upon their stored lexicon in order to retrieve and recall words from prior knowledge. As such, the nonword repetition task mitigates the likelihood of studying a subject's ability to use their long term memory or lexical abilities and can represent a purer assessment of the contribution of the phonological loop to cognition. (Susan E. Gathercole et al., 1997; Coady & Evans, 2008).

General guidelines of a Nonword Repetition Task: An extensive amount of the cited research in this paper utilizes an NRT. A summary of one administered in Gathercole et al., 1997 (which

will be elaborated in the next section), called the *The Children's Test of Nonword Repetition* (S. E. Gathercole et al., 1994) is provided below:

A child is tested on 40 nonwords, in four different lists, 10 nonwords each. The lists are two-, three-, four-, and five- syllables long (In other words, 10 contain two syllables, 10 contain three syllables, 10 contain four syllables, 10 contain five syllables). Nonwords that would pertain to the two syllable boundary include stimuli such as *flechy, sokis, pallot, fornick, sneeshy, morpest, vanit, trappid, dickle,* and *lantive*. The child is given the list of words, and asked to repeat them while the experimenter's mouth is covered to prevent lipreading. When the subject recites all nonwords correctly, the experimenter moves on to the next syllable-length list. Failure to recall the list terminates the test. The longest syllable-length list is counted.

Language learning device:

The nonword repetition task has gained notoriety as a successful tool to analyze the contribution of phonological working memory to vocabulary acquisition and the Gathercole and Colleague's 1997 study tested its efficacy further through comparisons to other learning tests in "Phonological Short-Term Memory and New Word Learning in Children." Their intention was to further understand what drives children's development of vocabulary words, thus, four different experimental tasks were analyzed in comparison to children's vocabulary size. Sixty-five five-year-old children partook in an experiment in three parts with eleven tests. The tasks were as follows: two tests that analyzed phonological working memory (digit span, nonword repetition), and three measures of vocabulary tests, two tests to measure nonverbal skills, and four-word learning tasks. Their findings from the 65 children provided evidence that high scores

on the nonword repetition task correlated significantly to a participant's vocabulary test scores, however also found that lexical knowledge had an influence on results of nonword repetition tasks, meaning while the nonword repetition task is likely a more accurate representation of the phonological loop, both phonological working memory and lexical knowledge are almost certainly measured in nonword repetition tasks. Further, in looking at the results in another light, it appears that lexical knowledge and phonological working memory are closely linked, which perhaps may be more of an indicator of the phonological loop as a model (**to be discussed at the end).

Language acquisition:

Roy & Chiat's 2004 study "A prosodically controlled word and nonword repetition task for 2- to 4-year-olds: evidence from typically developing children" responded to the growing notoriety of the nonword repetition task as a measure of language learning, and tested to see if it could work on younger children. Testing the nonword repetition task on younger children could help show the relevance of working memory and the phonological loop to language acquisition. A nonword repetition task was carried out on 66 children between two to four-years of age. A matching task between 18 words and 18 non-words was enacted, with varying length and prosodic structure. To compare the results of the nonword repetition task to vocabulary size, a receptive vocabulary assessment was performed. The nonword repetition task was found to elicit high levels of response from the 2 to 4-year olds and was successfully able to distinguish the differences in development of their repetition skills. Roy & Chiat concluded that the nonword repetition task could aptly test young children, meaning, in conjunction with other studies, that phonological working memory influences language acquisition even at as young as two years

old. Further, if the nonword repetition task can provide significant parallel to vocabulary acquisition, low nonword repetition tasks at a young age can be a measure of a potential precursor language deficit even at a very young age. (Roy & Chiat, 2004).

To reiterate: since the nonword repetition task tracks a subject's ability to recall words without semantic content, an individual cannot recall their stored lexicon, and the nonword recall task is thus a more apt representation of an understanding of sounds (the phonological store), and an ability to repeat them during a short period of time (the articulatory process). With the nonword repetition task's significant relationship to receptive vocabulary, there is reason to believe that the phonological loop has a role in learning words and thus language acquisition. Plainly, the nonword repetition task mirrors the phonological requirements a child must have to learn a novel word.

Foreign-language:

This can be true for native language acquisition, as shown above with vocabulary development in children, as well as foreign language acquisition. Elisabet Service's study, "Phonology, Working Memory, and Foreign-language Learning" (1992) found that the repetition of English nonwords was a strong predictor of Finnish children's abilities to learn the language (E. Service, 1992). Service's study was conducted over a three year period, and consisted of three tasks. The first was a pseudoword repetition task, which is another term for the nonword repetition task. The second was a pseudoword copying task, and the third was comparing syntactic-semantic structures, which required the participants to match syntactic pairs of Finnish sentences. These tests were compared to English and mathematics grades, and found that the ability to represent any form of novel phonological material would link to foreign language

acquisition skills. They concluded that the copying and repetition of novel foreign language words, that is a commonplace learning process of a foreign language, is linked to phonological working memory.

Language disorders:

Impairments of the phonological loop, both in the phonological store and the articulatory process, have been linked to language disorders. A 1990 study by Gathercole & Baddeley titled, "Phonological Memory Deficits in Language Disordered Children: Is There a Causal Connection?" conducted a study where a group of students with language disabilities *(the study is old and uses "children with disordered language development… do people still say that?)* were compared to two control groups: one group had comparative verbal abilities and the other comparative nonverbal intelligence. Their findings were that the children with the language disorder performed lower at recalling single nonwords (a marker of phonological retrieval), and recalling long word lists than the children with the same verbal abilities at a younger age. It appears clear that these children had a deficit in the phonological loop, in particular as their phonological working memory appeared to be disordered as they were sensitive to phonological similarities in word lengths up until the longest list. As such, their research was an original suggester that the nonword recognition task be used to test language disorders.

Further scrutiny of the nonword repetition task: a test for language impairments:.

The 2008 review, "Uses and interpretations of non-word repetition tasks in children with and without specific language impairments (SLI)" by Jeffry A. Coady and Julia L. Evans gathered studies that have used the task for various measures of language learning in children

with normal language development (NL) as well as those with specific language impairments (SLI) (Coady & Evans, 2008). The paper makes the point that was acknowledged previously in Gathercole and colleague's 1997 study "Phonological Short-Term Memory and New Word Learning in Children," Recent uses of the NRT seem to accept it as a measure of phonological working memory capacity in spite of the fact that researchers have consistently acknowledged that the task taps many language processes, including speech perception, phonological encoding, phonological memory, phonological assembly and articulation." The paper argues that because so many research studies have shown that the nonword repetition task has various language learning uses, it is a powerful tool for identifying language impairments in children.

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