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# Reversing Ribot: Does regression hold in language of prodromal Alzheimer's disease?

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ABSTRACT

We consider the regression or retrogenesis hypothesis, which argues that order of acquisition in development is reversed in neurodegeneration or pathology. Originally proposed as a regression hypothesis for the study of memory disorders, specifically retrograde amnesia, by Ribot (1881), it has been extended to the study of brain aging and pathology and to language. We investigate this hypothesis in a new study of language development, aging, and pathology. Through interuniversity collaboration using a matched experimental design and task, we compare production of complex sentences containing relative clauses by normal monolingual children during normal development, healthy young adults, healthy aging adults, and aging adults diagnosed with mild cognitive impairment, a recognized potential harbinger of Alzheimer's disease. Our results refute the regression hypothesis in this area and lead to potential syntactic markers for prodromal Alzheimer's disease and predictions for future brain imaging analyses.


## 1. Introduction

In early development of psychology as a science, French psychologist Theodule Ribot postulated Ribot's law of regression or reversion (Ribot, 2012, originally published 1881). For Ribot, "It is a well-known fact in organic life that structures last formed are the first to degenerate... in the biological world, dissolution acts in a contrary direction to evolution... the new perishes before the old, the complex before the simple" (2012, p. 127). Regarding memory, this regression hypothesis (RH) states that most recently acquired memories are lost first, with older memories retained longer, as in certain forms of amnesia due to brain injury (see also Freud, 1891).

Some more recent neuroscientific work regarding cerebral degeneration has supported a "last developed–first atrophied" hypothesis or retrogenesis theory (e.g., Reisberg et al., 1999, 2002), arguing "the higher cognitive association areas, which mature after the primary areas, show the first signs of functional decline and grey matter atrophy" (Jacobs et al., 2011, 154). However, in a recent study of protracted white matter maturation, areas showing protracted maturation were not the first to show age related changes (Westlye, 2010).

With regard to memory, some evidence such as in Alzheimer's disease (AD) provides support for Ribot's hypothesis; for example, Reisberg et al. (1999) and Sadek et al. (2004) report that a group of individuals with probable AD revealed "temporally graded memory loss with selective preservation of older information" on a Remote Memory test (Sadek et al., 2004, 692). (See also Beatty, Salmon, Butters, Heindel, & Granholm, 1988; Squire, Slater, & Chance, 1975.) However, in certain pathologies, such as semantic dementia, evidence has revealed a reverse temporal gradient wherein more recent events are remembered better than earlier ones (Graham & Hodges, 1997; Graham, Pratt, & Hodges, 1998; see also Baddeley & Warrington, 1970).

Evidence to date such as the above thus does not support Ribot's conjecture across the board, meriting its further study, which we pursue here.

### 1.1. Language

Ribot had proposed of the RH, "This law, general when applied to memory, is only one phase of a still more general law in biology" (2012, p. 127). Accordingly, he extended his search for evidence to

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the study of bilingual aphasia, predicting, for example, that last acquired languages are lost before native languages (cf. Obler & Mahecha, 1991; Pitres, 1895); although this pattern of loss in multilingualism does not necessarily replicate and is clearly confounded with many aspects of language knowledge, such as language proficiency, as well as age at acquisition (e.g., Paradis, 2004).

The RH was subsequently tentatively applied to the study of language development. Linguist Roman Jakobson (1941/1968, 2004) predicted that what is acquired last in language acquisition is lost first in a structured path of language dissolution—that is, "aphasic losses reproduce in inverse order the sequence of acquisition in child language" (Jakobson, 1941/1968, 78). He observed that in the acquisition of phonology, a Czech /ř/, a raised alveolar nonsonorant trill, is acquired late by Czech children and is lost early by Czech aphasics (Gleason, 1993, 174; after Jakobson, 1941/1968). Similar to Ribot's proposal in the domain of memory, Jakobson's hypothesis sought to link the biological foundations of language acquisition with those of language loss in a precise way based on "structural laws" of linguistics.

Early psycholinguistic work to test the RH frequently compared the language of adult aphasics with that of normally developing children, often in the area of phonology, with some extensions to sentence-level phenomena (e.g., papers in Caramazza & Zurif, 1978; Gleason, 1978). Later work extended comparisons to second language acquisition and attrition (e.g., Hyltenstam & Stroud, 1993; Hyltenstam & Viberg, 1993). Interpretation of results from these studies was vexed by numerous factors, such as the complexity and nonuniformity of aphasia types and/or of second language acquisition (Gleason, 1993; Obler & Menn, 1982; Pearce, 2005); as well as variation in methodology across first language and pathological or adult second language study. Many later tests of the hypothesis suffered from the absence of a sound "developmentally derived order of complexity" in linguistic areas studied (Goodglass, 1978, 107). Not surprisingly, results from previous studies in the area of language have been at best mixed or equivocal, suggesting the most prevalent conclusion of an apparent intractability of empirical study of the RH. (See DeBot & Weltens, 1991, for review and analysis.)

### 1.2. Aim

Our aim in this paper is to begin to reevaluate the RH in the domain of language and to add to earlier psycholinguistic studies whose results, although undeniably important, may have been confounded by numerous factors. We choose an area of language where we have firm evidence on first language acquisition, where properties of developmental ordering have been argued to have a universal component, and where a uniform methodology is possible. We compare these findings to those from a population with mild cognitive impairment (MCI), a known precursor to AD in which recent neuroscientific study of MCI suggests that specific hypotheses can now be generated regarding a course of cortical degeneration in the pathway from MCI to AD (e.g., Desikan et al., 2009; Greene & Killiany, 2010; Hanggi, Streffer, Jancke, & Hock, 2011; Harasty, Halliday, Kril, & Code, 1999; Spreng & Turner, 2013).

We focus on an area of syntax development, namely relative-clause development, recognizing that Jakobson had suggested that "phonological, as well as grammatical components of language are subject to the same principle of linguistic stratification" (Holmes, 1978, 87) and recognizing that relative clauses reflect essential properties of language knowledge such as embedding and recursion.

### 1.3. First language acquisition of relative clauses

We tested language in MCI as well as in healthy young and older adults in the same manner in which we previously studied first language acquisition of relative-clause structure, a fundamental component of language knowledge (Flynn & Lust, 1980). In that child study, we experimentally tested the hypothesis that lexically headed relatives such as in (2) were acquired later than headless relatives as in (1), which provided a developmental precursor.[1] (See also Lust, Foley, & Dye, 2009.[2]) Our hypothesis was confirmed.

1. I want [what Joan has bought]. (Headless relative: first developed).
2. I want [[the book [which Joan has bought]]]. (Lexically headed relative: later developed.)[3]

Elsewhere we argue that this developmental course may have a universal dimension, as data from first language acquisition of Korean, Tulu, French, Quechua, and other languages show converging developmental effects (Flynn, Foley, Gair, & Lust, 2005; Foley, 1996; Somashekar, 1999; see also Flynn & Foley, 2004; Flynn, Foley, & Vinnitskaya, 2004; Flynn & Lust, 1980; Lust, Flynn, & Foley, 1996; Lust, Flynn, Foley, & Chien, 1999). Converging evidence is also available from studies of child natural speech (Hamburger, 1980; cf. Limber, 1973).

Headless relatives may provide a form of universal precursor by which a foundation is provided for the acquisition of various language-specific forms of relatives (cf. Foley, 1996). Relative-clause structures are complex, involving embedding of one clause in another, empty elements or null sites, and binding of the anaphora involved in interpretation of the null sites.

We tested our hypothesis with a task of Elicited Imitation (EI) by young children of headed and headless relative clauses through an experimental design, which we replicated in our current study.[4] Stimulus sentences varied two within-group factors: Relative Clause Head Type (Lexically Determinate Headed, Indefinite ("thing") Headed, and Headless) and Relative Clause Functional Role of the gap (subject or object) in the relative clause, providing a $3 \times 2$ factorial design. A distinction between a lexical and indeterminate "thing" head tested whether an effect of lexical headedness in contrast to headless relatives would be due to the syntactic or the semantic difference between them. If semantic indeterminacy were responsible for this distinction, then the indeterminate head ("the thing") should parallel the headless in acquisition; if a syntactic factor, then it should parallel the determinate lexical headed. A between-groups factor tested 96 children, ages 3.5–7.6 in eight 6-month age groups.

### 1.4. Testing the RH

On the basis of biomarker assessment including brain imaging, AD has been estimated to progress through a "pathogenic cascade", possibly 10–25 years before clinical manifestation (e.g., Langbaum et al., 2013); thus involving a protracted apparently silent development (e.g., Braak & Braak, 1991; Jack, Albert, & Knopman, 2011; Reisberg et al., 1999, 2002) before cognitive changes are evident.

[1] The hypothesis did not require specific timing of acquisition of headed and headless relatives. It proposed that lexically headed relatives required headless relatives as a precursor in the sense that they existed when lexically headed relatives were acquired.

[2] The underlying representation of what we term "headless relatives" (e.g., (1)) is debated. For example, if the form "what" were treated as occupying a head position in syntax, these would not be truly headless and rather termed simply "free relatives". We use the term "headless" to describe these relative clauses in terms of the absence of their lexical nominal head.

[3] The lexical head is underlined in (2).

[4] The complete design of this study (Flynn & Lust, 1980) along with materials, administration standards, and scoring criteria, as well as original audio recordings, have been archived in an experiment bank available through www.clal.cornell.edu/vcla and provided the basis for our comparative study in this paper.