

**The Contribution of the Endogenous and Exogenous Factors to the Three  
Components of Working Memory among Adolescents and Adults with  
Intellectual Disability:  
The Impaired, Stable and the Compensatory Trajectories**

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Ph. D. Thesis

Submitted to the Senate of Bar-Ilan University

Ramat-Gan, Israel

July, 2018

## Abstract

The present study is divided into two parts. The aim of the first part was to examine developmental trajectories of working memory among individuals with intellectual disabilities (IQ = 40-70,  $N = 123$ ) (hereinafter ID). Of the participants, 63 had NSID (non-specific intellectual disability), and 60 had Down Syndrome (DS). They were grouped in three age cohorts: adolescence (ages 16-21), young adulthood (25-40) and later adulthood (41-55).

Studies of working memory among individuals with ID have tried to ascertain whether differences exist between the working memory of ID individuals and those with typical development. Our study offers several innovations: a. For the first time, components of working memory development were tested among individuals with ID in three age cohorts, from adolescence to later adulthood; b. Development was tested according to three possible trajectories (Fisher & Zeaman, 1970; Lifshitz-Vahav, 2015): the impaired trajectory (IT), the stable trajectory (ST) and the compensatory trajectory (CT); c. Working memory was tested according to two models: the three-component model of Baddeley (Baddeley, 2007; Baddeley & Hitch, 1974) that includes the phonological loop, the visuospatial sketchpad and the central executive, and the vertical-horizontal model (Cornoldi & Vecchi, 2003). This latter model postulates that working memory is determined by the degree of required control, that is, the demands and cognitive load (CL) inherent in the task beyond the modality. An integrative scientific research review of working memory studies among populations with ID (Lifshitz, Kilberg, & Vakil, 2016) found that only a combination of the two models can explain working memory performance among individuals with ID. Therefore, three levels of task load (low, medium and complex) were tested in each component.

The second part of the study examined the applicability of the Cognitive activity theory (Wilson & Bennett, 2003, 2005) to a population with ID. It was conducted only among participants age 20 and older. We tested the contribution of endogenous factors (age, etiology and intelligence) and exogenous environmental factors (participation in leisure activity) on the working memory of participants.

To examine working memory we made use of tests at three cognitive levels (low, medium and complex) in each of the working memory component: the phonological loop, the visuospatial sketchpad and the central executive. Working memory in the phonological loop was examined through three tests: the digit-span forward test, the forward word span test and

the non-word recall test. For the visuospatial sketchpad working memory test, use was made of three tests: the visual span test, the Corsi test and the matrix test. Central executive working memory was examined by means of six tests. Three of the six examined the phonological ability of executive functions: the selective span test, the backward digit span test and the verbal double task test. The other three tests examined spatial ability of the central executive: the starting position selection test, the backward spatial span test and the visual spatial double task test.

To test the effect of life style and leisure time activity on the development of working memory among individuals with ID, NSID and DS, use was made of the Participation in leisure time activities questionnaire (Wilson & Benet, 2005), adapted for populations with ID (Lifshitz-Vahav, Shnitzer, & Mashal, 2016).

Regarding the developmental trajectory of working memory from adolescence (16-21) to later adulthood (41-55), the trajectory was found to be similar among individuals with NSID and DS. However, a differential developmental trajectory was found for phonological working memory and spatial working memory. In the phonological loop and central executive in phonological modality there was an increase in working memory achievements from adolescence (16-21) to young adulthood (25-40).

Our findings support the hypothesis of the compensatory age theory (Lifshitz-Vahav, 2015) about the contribution of chronological age to the development of cognitive abilities (verbal working memory) in populations with ID. Apparently, people with ID are capable of benefiting from life experiences and exposure, and of developing their abilities at a later age. This finding counters the assertion stated in the definition of ID (DSM-5; American Psychiatric Association [APA], 2013) that individuals with ID lack the ability to learn from experience.

Nevertheless, in the verbal working memory (the phonological loop and central executive in phonological modality) was found a decline from young adulthood (25-40) to later adulthood (41-55). In the visuospatial sketchpad and central executive in spatial modality tasks, a non-significant moderate decline was found from adolescence (16-21) to young adulthood (25-40) and from young adulthood to later adulthood (41-55). A significant decline was reflected between adolescence and later adulthood.

Regarding differences in working memory pertaining to the various components and etiologies it was found that: a. achievements among individuals with NSID were significantly higher than among individuals with DS in verbal working memory (in the phonological loop

and in the central executive) above and beyond the age cohort; b. a performance hierarchy was found for the various modalities above and beyond the age cohorts in the two etiologies. Among individuals with NSID and DS, working memory achievements in the central executive were significantly lower than achievements in the phonological loop and the visuospatial sketchpad. While no significant difference was found between achievements in the phonological loop and the visuospatial sketchpad among individuals with NSID, achievements among individuals with DS were significantly lower in the phonological loop than in the visuospatial sketchpad; that is, the three components model (Baddeley, 2012) that includes the phonological loop, the visuospatial sketchpad and the central executive, can explain the functioning of working memory in populations with ID where difference emerged between individuals with NSID, and people with DS regarding the hierarchy of the phonological loop and the visuospatial sketchpad, a difference that characterizes the etiological phenotype. The findings of our study confirm the cognitive phenotype profile characteristic of individuals with DS.

Regarding the effect of task load level on each of the working memory components and etiologies, a similar effect was found for task load on achievements and on developmental trajectories from adolescence to later adulthood among populations NSID and DS: in the phonological loop and the visuospatial sketchpad, achievements in complex loads were significantly lower than in low and medium load levels. In the verbal and spatial central executive, achievements at low load levels were significantly higher than at medium and complex load levels. An effect of load level was found on the developmental trajectory of the phonological loop and the verbal central executive but not in the visuospatial sketchpad and the spatial central executive.

The findings of our study support the vertical model of Cornoldi and Vecchi (2003). This model reflects the degree of control level (CL) required, which is defined as the amount of active processing required to manipulate the information maintained in a temporary memory system. The vertical model of Cornoldi and Vecchi (2003) is parallel to the attention level concept proposed in the TBRS model of Camos and Barrouillet (2004). According to the findings of our study, individuals with NSID and DS succeed in coping better with those tasks that require a lower level of attention for storing and processing. At the same time, they demonstrate more salient difficulties in tasks requiring high attention levels. These findings indicate the taxonomic effect of the task in each of the memory component for each of the etiologies .

As to the effects of endogenous (age) factors and exogenous (participation in cognitive activities and leisure activities) factors on working memory it was found that chronological age contributed negatively to scores in three tests: non word task, forward digit span and backward digit span task. In other words, with age a decline was found in these test results. In contrast, level of participation in cognitive activities and leisure time activities, when two crystalline verbal measures were introduced as measures that reflected the basic cognitive level of participants, contributed significantly to scores in three tests: visual span task, selective span task, and backward digit span task. In other words, the higher the level of participation in cognitive and leisure time activities, the higher were the scores in two verbal working memory tests and one test of visual-spatial working memory, for two of the populations., that according to the endogenous measures of the participants cognitive level.

Our findings provide support for the cognitive activity theory (Wilson & Bennet, 2005), according to which participation in cognitive activities and in leisure activities contributes to contemporary cognitive functioning and moderates the effect of endogenous factors such as age.