The Link between Cross-Modal Synchronization and Arithmetic and Reading Skills among Elementary School Children

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Abstract

The aim of the present study was to examine the relationship between cross-modal synchronization (vision and hearing) and the development of arithmetic and reading skills among typical Arabic-speaking children. This aim was based on research findings indicating the importance of arithmetic skills and language abilities in daily life. For the most part, what has been examined in previous studies was the relationship between arithmetic skills and each sense separately (intra-modal synchronization), in other words, the relationship between arithmetic skills and processing by the visual sense or the auditory sense, and few studies have examined the relationship between language skills and cross-modal (visual-auditory) synchronization.

The present study was based on three bodies of theoretical knowledge: the a-synchronization theory that was developed by Breznitz (2003), which was based on the contention that cross-modal synchronization is of crucial importance to the accurate and proper processing of information. In other words, processing is better if information arrives in the processing system from a number of senses and fits in both in terms of content and of time (Breznitz et al., 2010; Breznitz & Misra, 2003; Sela, 2014); the Triple Code Model, developed by Dehaene and Cohen (1995) – a neuro-psychological and anatomical model that links language and arithmetic skills and describes the representation and perception of numbers through three mental representations: analog (quantitative), auditory-verbal (words), and visual (symbols); the theory developed by Ram-Tsur et al. (submitted) to explain the co-morbidity of deficiencies in the development of reading and arithmetic skills, from which they developed a model indicating a correlation between cross-modal a-synchronization and arithmetic skills. Their contention was that this correlation is mediated through language skills.

Therefore, the present study examined the development of cross-modal synchronization through the measures of reaction time and extent of accuracy in relation to age, and the synchronization of two modals – visual and auditory – with arithmetic and reading skills. This connection was examined through the contribution of cross-modal synchronization to an explanation of the development of arithmetic and reading skills, in addition to the

contribution of the cognitive abilities: attention and concentration, memory and intelligence. In addition, the study examined whether the contribution of cross-modal synchronization to reading and arithmetic skills decreased with age.

To examine the study hypotheses, the following variables were defined:

Independent variables – reaction time in cross-modal synchronization, extent of accuracy in cross-modal synchronization, reaction time in intra-modal synchronization, extent of accuracy in intra-modal synchronization, memory, attention and concentration, and intelligence.

Dependent variables – reading skills, arithmetic skills.

The study was carried out in two parts: a longitudinal (developmental) study that examined first grade pupils and a year after the same pupils in second grade; and a latitudinal (comparative) study in which the participants were pupils in grades four and six. This part of the study also included the results of the tests taken by the second grade pupils in the longitudinal study. Hence, a comparative sequence of three grades was obtained –second, fourth and sixth grade pupils.

The study population included 237 typical Arabic speaking pupils who attended elementary schools in the center of Israel. The study participants consisted of 185 pupils who were divided as follows: in the longitudinal study participated 52 pupils in first grade, and a year later when they studied in second grade; the comparative study included the very same 52 pupils when they studied in second grade, 93 fourth grade pupils and 40 sixth grade pupils.

The methodology used to examine the study hypotheses included internationally approved tests. Hence, reading skills were examined by written tests, arithmetic skills were examined by written tests and computerized numerical processing experiments, and cross-modal synchronization and intra-modal synchronization were examined by computerized behavioral experiments.

In general, the findings revealed partial confirmation of the hypotheses. Hence, a correlation was found between cross-modal (visual and auditory) synchronization and arithmetic skills (both in written tests and in computerized numerical processing experiments). In addition, the contribution of cross-modal synchronization to arithmetic

skills was found to be more significant in comparison to the contribution of the intra-modal synchronization variables (reaction time and extent of accuracy) and the cognitive abilities: attention and concentration, memory and intelligence. However, no correlation was found between cross-modal synchronization and reading skills, and cross-modal synchronization did not contribute to those skills.

In the developmental (longitudinal) study, the findings revealed that cross-modal synchronization among second grade pupils was better in comparison to first grade pupils. However, in the comparative (latitudinal) study, age differences were found in the cross-modal synchronization in the measure reaction time, but no age differences were found in the extent of accuracy. As to the reduced contribution of cross-modal synchronization to reading and arithmetic skills with age, the hypothesis was not confirmed in the longitudinal study, but it was partially confirmed in the latitudinal study. Hence, it was found that the contribution of cross-modal synchronization to arithmetic skills declined among fourth grade pupils in comparison to second grade pupils , but no differences were found between fourth grade pupils and sixth grade pupils, and no differences were found in the strength of the correlations between cross-modal synchronization and reading skills.

It was further found that attention and concentration contributed to cross-modal synchronization, to arithmetic skills and to reading skills regardless of age, and that intelligence contributed to cross-modal synchronization and to arithmetic skills regardless of age.

The present study has a few limitations. First, we examined the contribution of cross-modal synchronization to reading skills among Arabic speaking pupils, hence the findings cannot be generalized to the entire population of typical children speaking less complicated, non-diglossic languages.

Another limitation might relate to the fact that the arithmetic skills were examined by both written and computerized tests, and that computerized tests were also used to examine cross-modal synchronization and intra-modal synchronization, but the reading skills were examined by written tests only, and that might have affected the findings.

The contribution of the present study might be both theoretical and practical. Theoretically speaking, the findings may contribute to expanding the body of knowledge

about a-synchronization. Until now, cross-modal synchronization was examined among dyslexic adults, but in the present study it was examined among typical children in elementary schools in the Arab sector. Therefore, the uniqueness of the study lies in its being the first to examine the correlation between cross-modal (vision and auditory) synchronization and reading and arithmetic skills among typical children, and thus, the findings may contribute to an understanding of conceptual processing and its connection to the development of reading and arithmetic skills among children. Unlike previous studies that focused on one aspect of the source of difficulties and examined slowness in reading, inaccurate reading and slow or inaccurate retrieval of basic arithmetic facts from memory, the present study was based on a holistic examination that included a combination of two aspects (reading and arithmetic) through two research systems: a longitudinal (developmental) study and a latitudinal (comparative) study, and the correlation between cross-modal synchronization and these skills.

Another contribution of the present study is reflected in the examination of a new direction, recently proposed but not yet confirmed empirically, of a correlation between the development of arithmetic and reading skills and synchronization, and between conceptual information processing received through the visual and auditory senses (Ram-Tsur et al., submitted).

From a practical point of view, the findings may contribute to an understanding of conceptual perception processing and its connection to the development of reading and arithmetic skills among children. Thence, it will be possible to develop an early, focused intervention to improve cognitive abilities that constitute an important basis for the development of these skills, and based on the findings, it will be possible to indicate a new direction for an early intervention that might improve various learning skills, i.e., cross-modal synchronization, at a young age. Furthermore, such an intervention might improve cognitive abilities such as attention, concentration and memory, which based on the findings, contribute greatly to achievements and to better performance.

The importance of the study increases in light of the fact that understanding conceptual processing and its connection to the development of arithmetic skills is a primary goal of

science education in Israel and throughout the world (OECD, 2010), mainly because of the low results that Israeli pupils achieve in international tests in mathematics.

Additionally, the uniqueness of this study is reflected in an understanding of the cognitive contribution of each of the cross-modal synchronization components to conceptual processing in the learning process: reaction time which indicates a high ability of attention and concentration and fast retrieval from memory during the performance of written reading tasks and written or computerized arithmetic tasks, and the extent of accuracy which indicates a high level of cognitive abilities: attention and concentration, memory and intelligence during performance of reading and arithmetic tasks.