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New model of mapping difficulties in solving analogical problems among adolescents and adults with intellectual disability

Hefziba Lifshitz *, Itzhak Weiss, David Tzuriel, Moran Tzemach

School of Education, Bar-Ilan University, Ramat-Gan 52900, Israel

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ABSTRACT

The main goal of the study was to map the difficulties and cognitive processes among adolescents (aged 13–21, $N = 30$) and adults (aged 25–66, $N = 30$) with mild and moderate intellectual disability (ID) when solving analogical problems. The participants were administered the *Conceptual and Perceptual Analogical Modifiability* test. A three-fold tailored dynamic assessment (DA) model for mapping difficulties was constructed based on Sternberg's analogical components model (encoding, inference, mapping, application): (a) mapping pre-teaching difficulties; (b) assessing the level of mediation; and (c) analyzing post-teaching responses. Another goal was to find out whether participants receiving "tailored" mediation would receive higher scores than participants receiving the standard DA procedure (adolescents aged 14–20; $N = 30$) and adults (25–55, $N = 31$). Repeated measures MANOVA of time × age × ID level indicated significant pre to post-teaching improvement across all age groups and ID levels. The adults gained more from mediation than the adolescents. The tailored DA model was more effective in producing change than the standard DA model. The greatest difficulties in the pre-teaching stage were in inference and mapping of perceptual analogies, where the participants received the highest level of mediation. Stepwise regression analysis indicated that inference, ID level and age predicted modifiability in the application of conceptual analogies, whereas encoding, ID level and mediation for inference predicted modifiability in the application of perceptual analogies.
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Analogy is ubiquitous in human learning and discovery (Gentner, Holyoak, & Kokinov, 2001; Holyoak, 2005) and has long been viewed as a core component of intelligence (Spearman, 1927; Sternberg, 1977). Computational analyses as well as empirical evidence suggest that the processes of binding and mapping used in analogical reasoning require activation of the working memory (WM) system (Baddeley & Della Sala, 1996; Morrison, Holyoak, & Truong, 2001; Waltz, Lau, Grewal, & Holyoak, 2000), which in turn depends on developmental changes in the prefrontal cortex (Baddeley & Della Sala, 1996; Morrison et al., 2001). According to Baddeley and Hitch (1974), the WM utilizes the Central Executive, which includes the inhibitory control necessary for solving analogical problems (Morrison et al., 2001).

Reasoning by analogy refers to fluid intelligence (Snow, Kyllonen, & Marshalek, 1984) as opposed to crystallized intelligence (Cattell, 1963), and is considered a measure of general intelligence *g* (Spearman, 1927). The conceptual process involved in analogies is central to everyday learning. For example, orientation in the community is related to the understanding of analogical rules (i.e., a doctor is to a hospital like a teacher is to the school). Carrying out vocational skills is

* Corresponding author.
E-mail addresses: Lifshih1@mail.biu.ac.il (H. Lifshitz), weiss.itzhak@gmail.com (I. Weiss), Tzuriel@mail.biu.ac.il (D. Tzuriel), moranze@gmail.com (M. Tzemach).

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also related to an understanding of analogical rules (i.e., if nails of size X fit box X, then nails of size Y should fit box Y). It is therefore obvious why it is important to impart analogies to populations with intellectual disability (ID).

1. Identifying reasoning abilities of individuals with intellectual disability

Individuals with ID are typically characterized by poor language (Fink & Cegelka, 1982), limited vocabulary (Borkowski & Büchel, 1983), and inadequate verbal tools (Vygotsky, 1978). They have difficulties in dealing simultaneously with several aspects of a problem, in transferring a new strategy from one context to another (Brown, 1974; Brown, 1978; Budoff, 1987a; Tzuriel & Klein, 1985), and in understanding abstract relations between pairs of objects (Paour, 1992b). They show relative lack of verbal rehearsal (Hulme & Mackenzie, 1992; Zeaman & House, 1970), lack of automatic identification of a presented stimulus (Das, 1985), inefficient short-term memory (Belmont & Butterfield, 1974; Reed, 1996) and difficulties in solving cognitive problems, especially analogical ones. Deficits in the WM system, and especially the executive function and inhibition control (Hulme & Mackenzie, 1992), make it difficult for individuals with ID to acquire adequate analogical reasoning. The above limitations and the belief that individuals with mild and moderate ID cannot go beyond a concrete level of reasoning (Inhelder & Piaget, 1958; Jensen, 1970) may prevent psychologists and educators from exposing these individuals to abstract cognitive problems.

2. Dynamic assessment (DA) of individuals with intellectual disability

The DA procedure is an active teaching process involving an individual's perception, learning, thinking, and problem solving (Caffrey, Fuchs, & Fuchs, 2008; Feuerstein, Rand, Hoffman, & Miller, 1979; Grigorenko & Sternberg, 1998; Haywood & Lidz, 2007; Swanson, 2000; Tzuriel, 2000; Tzuriel, 2001a). This procedure emerged from the structural cognitive modifiability theory (SCM) and the mediated learning experience theory as an alternative to static standardized assessment. It is aimed at modifying an individual's cognitive functioning and observing subsequent changes in learning and problem-solving patterns within the testing situation (Tzuriel, 2001a). It enables more adequate and accurate assessment than standardized normative tests for individuals with ID, including those with Down syndrome (Alony & Kozulin, 2007; Carlson and Wiedle, 1992; Lifshitz, Tzuriel, & Weiss, 2005), sensory impairment (Tzuriel & Caspi, 1992), emotional disturbance, and learning disability (Tzuriel, 2001a). It also helps individuals gain a better grasp of the nature of a task, draw upon important cognitive and meta-cognitive processes and, by addressing the affective realm, build feelings of competence (Lauchlan & Elliott, 2001). Büchel, Schlatter, and Scharnhorst (1997) and Hessels-Schlatter (2002) succeeded in teaching abstract reasoning to students with moderate ID. They demonstrated that it is possible to distinguish between gainers and non-gainers after training using a DA procedure. Lifshitz et al. (2005) administered the *CPAM* (*Conceptual Perceptual Analogies Modifiability*, Tzuriel & Galinka, 2000) to adolescents and adults with ID who achieved a mean score of 15.98 out of 20 on conceptual analogies and 16.71 on perceptual analogies.

In the current study we used the *CPAM* (Tzuriel & Galinka, 2000), which represents a classical model in the form of A:B::C:D and is based on Sternberg's (1977, 1985, 1986) four-component model: *Encoding* – identifying the relevant traits in each analogy and their maintenance in the working memory; *Inference* – detecting the relation between terms A and B in the analogy; *Mapping* – detecting the relation between terms A and C in the analogy; *Application* – matching the relationship between terms A, B to the relationship between terms C, D. The application component includes the *response which relates to* choosing the correct answer from among several alternative choices. The present study aimed to discover which of Sternberg's (1977, 1985, 1986) four thinking components constitute stumbling blocks for this population (encoding, inference, mapping, or application). Several models for explaining the thinking process of participants with typical development (TD) while solving analogies have been proposed (Bethell-Fox, Lohman, & Snow, 1984; Carpenter, Just, & Shell, 1990; Emerston, 1992). These methods were based mainly on verbal protocols, which are difficult to apply to populations with ID. In the current study, difficulties in solving analogies were mapped before and after intervention using a tailored DA (TDA) procedure constructed for this purpose. We examined whether differences would be found between participants who received mediation using the TDA procedure versus participants who received mediation by a standard DA (SDA) procedure. The TDA procedure differs from the SDA procedure in three aspects. In the TDA (a) there is an attempt to map the participants' difficulties in the four analogy components, (b) the participants are asked to be active and verbally analyze the analogy components before and after mediation, (c) mediation is tailored for each participant individually according to his/her response in the mapping the difficulties stage.

2.1. The influence of chronological age on the cognitive ability of individuals with ID

The influence of chronological age (CA) and fluid intelligence on the crystallized intelligence level of students with ID was examined in a series of studies (Facon & Facon-Bollengier, 1997; Facon & Facon-Bollengier, 1999) which indicated (1999) that CA explains 21% of the variance in crystallized intelligence. The authors claimed that longer life experience may aid individuals with ID succeed in some cognitive tasks and partly determines their mental age (MA). Their study was conducted on younger age groups, whereas ours focused on adolescents and adults. Lifshitz et al. (2005) found that adults with mild ID gained more from a DA procedure in teaching analogical reasoning than adolescents. Lifshitz and Katz (2009) found that CA contributed significantly to the explained variance of cognitive concepts of religiosity among Jewish adolescents and adults

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