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Intelligence and Mental Imagery in ID

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Abstract

After a presentation of the main model for conceptualizing and measuring intelligence, the importance of Mental Imagery in determining the cognitive performances in Intellectual Disability (ID) is underlined.

The study aims at investigating if mental imagery can moderate the effect of cognitive components (i.e., Factor IQ) on the degree of mental deterioration in adults diagnosed with ID.

The WAIS-IV, MoCA, and MIT (Mental Imagery Test) were administered in a sample composed of 40 subjects, age range 16-64 years, diagnosed with Mild or Moderate ID.

The results show that the WAIS-IV, MoCA, and MIT scores are significantly correlated. Imagery improves the effect of Verbal Comprehension, Visual Perceptual Reasoning and Working Memory factors in predicting the MoCA results.

A discussion about the use of mental imagery for planning rehabilitative interventions in persons with ID is presented.

Key words: Intelligence, Mental Imagery, ID, WAIS IV, MoCA, MIT

Introduction

Some theoretical models defined intelligence on the basis of the identification of a general factor (Spearman, 1927), which some authors have distinguished in two second-order components: the fluid intelligence factor (the basic neurobiological capacities) and the crystallized intelligence factor, i.e. acquired and consolidated knowledge (Horn & Cattell, 1966).

A different conception of intelligence, composed of a multiplicity of independent aspects, was presented by Thurstone (1938) and is now widespread: e.g., the theory of multiple intelligences (Gardner, 1983, 1999), and the triarchic theory of successful intelligence (Sternberg, 1988).

For the purposes of measuring intelligence, a mediating model was proposed by Wechsler (1939) who, together with a global IQ, proposed different factorial indices representing the different components of the complexity of intelligence.

But are all the components of intelligence actually represented in the measurement of intelligence tests, however complex and complete as the Wechsler scales? Or are other components in interaction when performing the tasks which define intelligence in these tests?

This problem has a clinical relevance when the assessment regards the ‘limits’ of the intelligence (e.g., in the Borderline Intellectual Functioning) or the threshold that defines the ID, in which many functions are impaired and this contribute to lowering in different ways the general intellectual abilities measured by the IQ. Deficits can affect separately functions such as verbal comprehension, reasoning and problem solving, planning and abstract thinking, conceptual skills, executive functions, judgment skills, but also scholastic achievements and learning from experience, compromising the general level of adaptation.

An important aspect that can be hypothesized to underlie many others functions, is Mental Imagery, not evaluated directly by intelligence tests.

Mental Imagery in Intellectual Disability

The imagination involves a particular form of mental representation, which produces and processes external objects without the related stimuli actually being present in the sensorial and perceptual systems (Paivio, 1971; Kosslyn, 1980; Kosslyn, Ganis, & Thompson, 2006). Like perception, imagery can be based on all sensory modalities; however, the image reconstruction of a 'perception without stimulus' elaborates experiences both cognitive and emotional, which can be reported and measured (Kosslyn, Behrmann, & Jeannerod, 1995; Pearson & al., 2015).

It is well known that the ability of visual imagination (e.g., of generation and transformation of images in the mind) can be impaired by the consequences of brain damage or syndromes involving ID (Symmes, 1971; Lebrato & Ellis, 1974; Porretta & Surburg, 1995; Roskos-Ewoldsen & al., 2006). Moreover, a subject stimulated to use imaginative skills may not be automatically able to apply them to the requested task; individual differences in the capacity to "work with images", existing in typical development, are accentuated when a general impairment of cognition (e.g., including the working memory) is present. Specific visual and spatial imagery deficits have been found in two genetic syndromes involving ID (Down and Williams), together with those of visual perception and working memory (Vicari, Bellucci & Carlesimo, 2006).

Neurobiological evidence supports the importance of the relationship between perceptual and visual-motor skills and cognitive abilities in ID. Blasi et al. (2007), administering the Wechsler Intelligence Scale for Children, the Bender Visual Motor Gestalt Test and the Developmental Test of Visual Perception, showed that children with ID had also a deficit in the perceptual organization correlated with the severity of ID. The results also suggested that spatial and cognitive skills may influence the information processing; therefore, the defective cognitive functioning in ID is not limited to higher cognitive functions, but involves also more basic functions. Since neurobiological processes and cerebral areas involved in perception have been demonstrated to be relevant also for imagining (Farah, 1985; Ishai, Ungerleider, & Haxby, 2000; Jeannerod, 2001; Bartolomeo, 2002; Slotnick, Thompson, & Kosslyn, 2012), mental imagery could be hypothesized as a variable, similar for many instances to the perception, influencing the overall mental efficiency.

Deficits of imaginative skills can affect other cognitive activities that require the use of mental representation (Courbois, 1996). Imagination begins to develop at 18-24 months but only when 6-7 years old children are able to develop the multiple components of imagery; they can generate and elaborate anticipatory images, and this allows reconstructing dynamic processes and predicting of the consequences of the actions. The development of the imagination implies a previous neurological, cognitive, affective-emotional maturation, as well as the presence of adequate interpersonal and environmental conditions, which are lacking in an atypical development; and this may have important repercussions on intellectual performance.

Ahsen (1985), proposing the "triple code theory", underlined that the activated and perceived mental image (*Imagery*) involves somatic and neurophysiological changes (*Somatic response*) that allows the organism, as a mind-body unit, to interpret the relationship between the mental image and the world (*Meaning*). This meaningful interpretation of the imagined experience, including one's own somatic reaction, puts the mind - thanks both to neuronal maturation and learning - in the condition of grasping the symbolic meanings of external reality, could be absent or impaired in persons with intellectual deficits.

In a condition of ID, the subject, unable to elaborate complex mental images, can fail in anticipating the consequences of his actions, and in recreating scenes in new ways than those experienced in reality.

Therefore, it seems relevant to deepen the relationship between imagery skills and intelligence in people with ID, hypothesizing that the lack of imaginative skills can interfere more in some tests in which these skills are most needed.

Experimental study

Aims

The study aims at investigating how specific mental imagery abilities can intervene in moderating the effect of cognitive components (i.e., Factor IQ) on the degree of mental deterioration in adults diagnosed with ID; and detect if some factors are more implied than others in these relationships.

Instruments

- *The Wechsler Adult Intelligence Scale - Fourth Edition (WAIS-IV;* Italian edition 2013) devised for assessing the cognitive abilities of adults aged between 16 and 90 years, providing a total score of IQ, representative of general intellectual ability, and four composite scores, which measure specific cognitive domains: Verbal Comprehension Index (VCI), Visual Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). Moreover, two indices of general and cognitive efficiency can be obtained grouping the four factors: GAI, General Ability Index; and CPI, Cognitive Proficiency Index.

- *Montreal Cognitive Assessment (MoCA*, Nasreddine & al, 2005): a short screening instrument, built for detection of cognitive impairment, consisting of several tasks which explore the following cognitive domains: visual-spatial abilities; naming; memory (delayed recall of words), attention, concentration and working memory, language, abstract reasoning; temporal and spatial orientation. The total MoCA score varies from 0 to 30; the cut-off of normality is 26. This score should be corrected for age and education (for the Italian version: Conti & al. 2015). The test has good psychometric characteristics, a level of reliability *alpha*=.69, and has been validated in 27 different countries in the world (Pawlowski & al. 2013).

- *Mental Imagery Test* (MIT, Di Nuovo, Castellano e Guarnera, 2014) includes a series of tasks involving the generation of images (starting from verbal stimuli proposed by the examiner) and their active manipulation. The eight tasks composing the test derived from different sources retrieved in mental imagery literature. These subtests require: to imagine some uppercase letters of the alphabet read by the examiner, deciding whether they contain curved parts or not (*Visualizing letters*); to examine mentally the contour of a letter F recalling in sequence the direction (internal/external) of its edges (*Brooks 'F' Test*); to imagine what hour a clock reflected in the mirror seems to indicate, now and after 10' (*Clock*); to visualize a large cube made up of many small cubes, previously seen, and saying how many corner and middle external faces it shows (*Cube*); to subtract in imagination parts from figures (*Subtraction of parts*); to explore mentally a map evaluating the distances between the elements present in it (*Map*); to imagine, according to sequential indications from the examiner, the paths of a dot moving in the space (*Imagined paths*); to visualize objects of different shapes, discriminating the wider from the higher (*Representation of shapes of objects).* The total score of the test has a good reliability (Cronbach's *alpha* ranging from .75 to .78 according to age) and validity, being able to discriminate the imaginative performances compared to those of pure perception or memory, both in normal subjects and with mental deterioration (Di Nuovo & al., 2014).

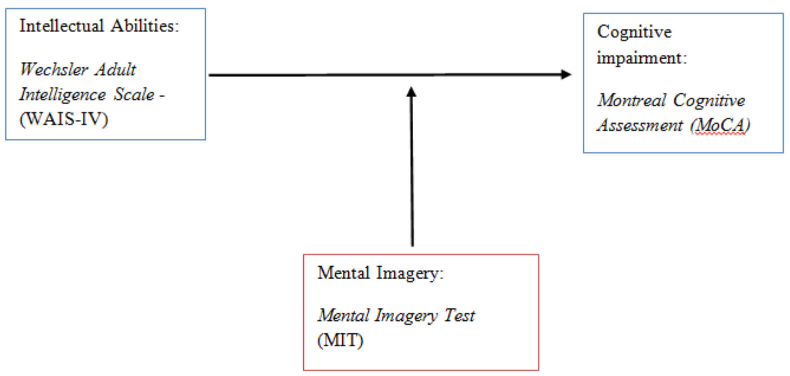
Sample

The sample of the study was composed of 40 subjects, 27 males and 13 females, inpatients of the O.R.T.U.S. Foundation, a structure for the rehabilitation of persons with diagnosis of ID.
All the subjects have been diagnosed with Mild or Moderate ID. The age range was 16-64 years, mean age 35.70 (s.d. 11.89). Informed consent was obtained from the participants or their families.

Hypothesis

According to the aims of the study, the hypothesis was to verify if the effect of intellectual abilities on cognitive impairment depends, in terms of sign and/or intensity, on the moderating effect of the Mental Imagery. The hypothesized moderation model is represented in Figure 1.

Here Figure 1 – Graphic representation of the moderation model



Data Analysis

Basic statistics for each variable, zero-order correlations with Bonferroni correction of probabilities for multiple comparisons, and hierarchical regressions were calculated by means of SPSS (version 20.0).
Linear structural equations models were calibrated to test the hypotheses using AMOS 21.0 (Arbuckle & Wothke, 1999). Firstly, a confirmatory factor analysis (CFA), using the maximum likelihood method, was used to test the fit of the models (Byrne, 2001). Several goodness-of-fit indexes were computed, including the chi-square (χ^2), the comparative fit index (CFI), the Tucker- Lewis index (also called Non-Normed Fit Index or NNFI), the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR). Because the χ^2 is highly sensitive to sample size (the larger the sample size, the more likely to reject the model), the ratio chi-square/degrees of freedom is frequently analysed. Kline (2005) recommended that a χ^2/df greater than 3 represents inadequate fit. The Akaike's Information Criterion (AIC), and the Bayesian Information Criterion (BIC) were also computed.
Following the Aiken and West (1991) method, we calculated the simple slopes of the interaction effects one standard deviation below and above the mean to examine the nature of the significant interactions. Interaction effects represent the combined effects of variables on the criterion or dependent measure; when an interaction effect is present, the impact of one variable depends on the level of the other variable.

Results

The intercorrelations for the main variables considered in the study are presented in Table 1. Results showed significant relationships between MoCA and all factor of WAIS-IV, except for Processing speed (IPS). The same can be said for the relationship between the MIT score and the cognitive domains of the WAIS-IV. Furthermore, there is a strong correlation between the MoCA score and the MIT score ($r=.70$, $p<.01$).

Here Table 1. Descriptive statistics and correlations of main variables (N=40)

	Mean	*SD*	*VCI*	*PRI*	*WMI*	*PSI*	*MoCA*
1. Verbal comprehension (VCI)	55.15	5.25	-				
2. Visual-perceptive reasoning (PRI)	52.50	7.88	.62**	-			
3. Work memory (WMI)	51.35	3.05	.58**	.60**	-		
4. Processing speed (PSI)	52.32	5.58	.29	.31	.25	-	
5. MoCA Total score	10.92	4.64	.68**	.51**	.55**	.25	-
6. MIT Total score	34.93	7.82	.61**	.61**	.56**	.24	.70**

** p<.01 (after Bonferroni correction)

CFA analysis.

The confirmatory factor analysis was conducted comparing two different models. The first model included the test with a single-factor structure, and for the WAIS-IV the two indices GAI (General Ability Index) and CPI (Cognitive Proficiency Index). The results of this first model have a significant chi-square value: $\chi^2_{(116)}$ = 295.30, p =.003. The NNFI and CFI values were below the threshold of .90 (NNFI= .87; CFI = .88; χ^2/df =2.48); the values of RMSEA and SRMR exceeded the critical threshold of .08 (RMSEA= .12, SRMR = .13). The values of AIC and BIC were 232.64 and 561.21 respectively.

The unsatisfying fit of the first model induced to test a second model considering separately the factors of the WAIS-IV (Verbal comprehension, Visual-perceptual reasoning, Working memory and Processing speed), with a second-order factorial structure. This second model presents better goodness indexes: $\chi^2_{(116)}$ = 190.05, p <.001, but χ^2/df =1.64; NNFI = .91; CFI = .92; RMSEA = .08; SRMR = .09; AIC= 158.78; BIC=231.46). Moreover, also the difference test ($\Delta\chi^2$ = 105.25, p <.001) suggests that this model is very different from the first, and preferable due to the better parameters, for analyzing the moderation effect in our variables.

Analyses of main predictors and moderating effects.

The table 2 shows the hierarchical regression results for the four cognitive domains of the WAIS-IV in predicting the assessment of cognitive impairment (MoCA). As shown in Step 1, the main effects of three of the four domains of the WAIS-IV on cognitive impairment are correlated significantly and positively: Verbal comprehension (β =.37; p<.05), Visual-perceptive reasoning (β =.38; p<.05), Working memory (β =.41; p<.001).

In step 2, the results indicate that the main effects are due to the strong presence of significant two-way interactions that represent a significant amount of additional variance in the results and produce a significant regression weight (Aiken and West, 1991).

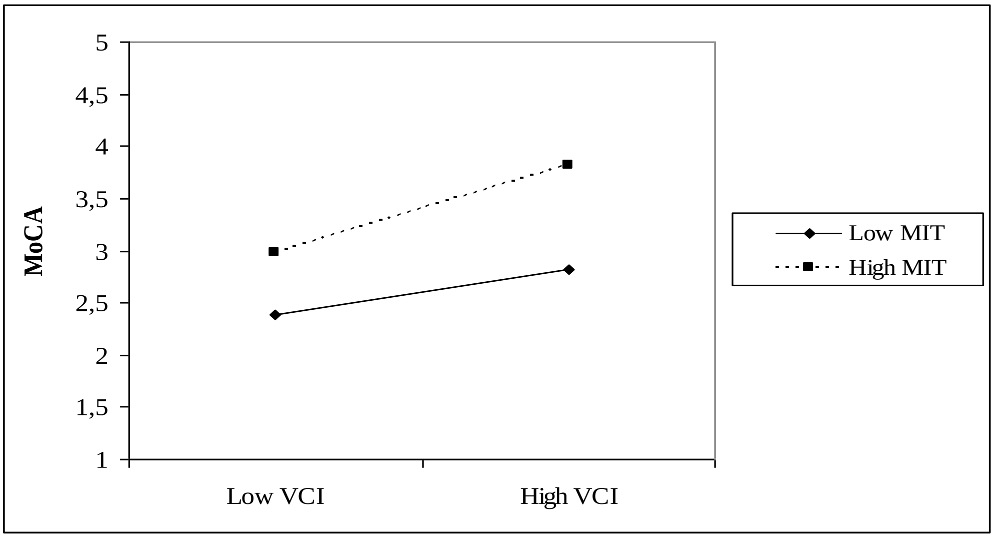
Here Table 2. Results of hierarchical regression analyses (standardized regression coefficients) including WAIS-IV factors as independent variables and MoCA as dependent variable.

	MoCA		
	Estimate	*S.E.*	*p*
Step 1			
Verbal comprehension (VCI)	.37	.07	.01
Visual-perceptive reasoning (PRI)	.38	.05	.01
Working memory (WMI)	.41	.08	<.001
Processing speed (PSI)	.21	.96	.12
Step 2			
MIT *x* VCI	.41	.14	.003
MIT *x* PRI	.70	.01	<.001
MIT *x* WMI	.53	.01	<.001
MIT *x* PSI	.03	.55	.78

The study of the slopes of interaction effects allows detecting the moderating effects.

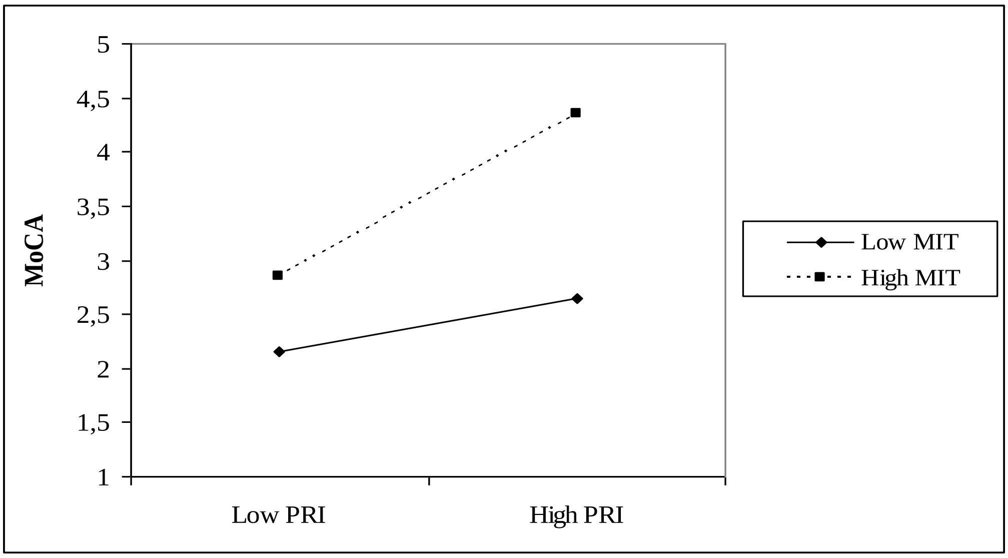
Figure 2 shows the significant interactions between the Verbal comprehension domain (VCI) and the total MoCA score. That is, mental imagery can improve the effect of the VCI in predicting the MoCA results. In fact, the relationship between the Verbal comprehension and the score of the MoCA score improves with the interaction of mental imagery.

Here Figure 2. Interaction between MIT and Verbal comprehension (VCI) in predicting MoCA



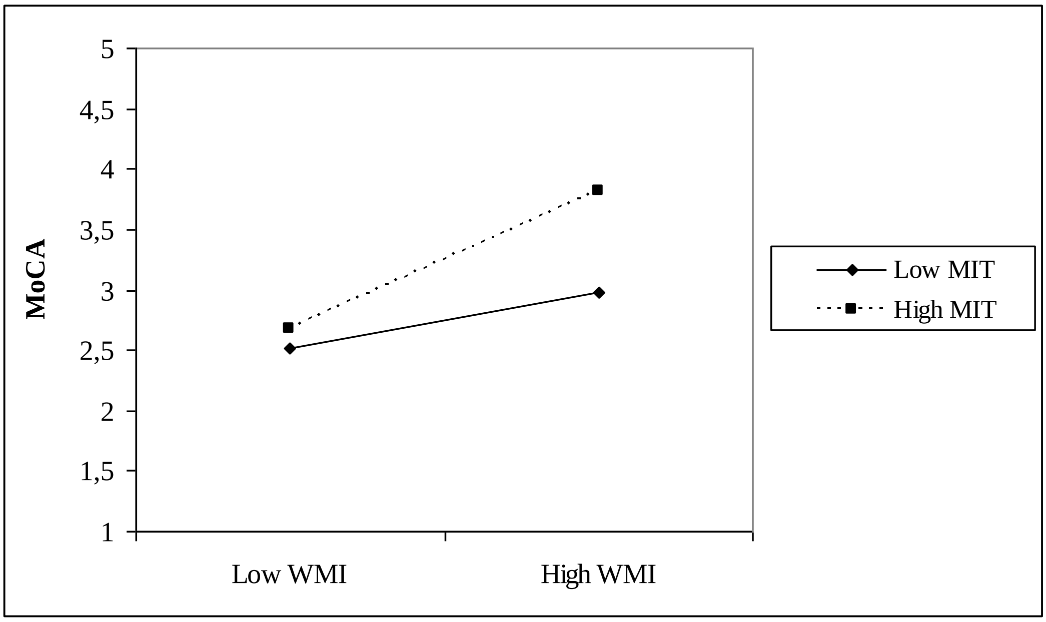
Similar results have been found with respect to the interaction between the cognitive domain of Visual-perceptive reasoning and mental images, but with an even greater effect. The positive impact of visuo-perceptual reasoning ability on cognitive improvement is strongly enhanced by the impact of mental images (Figure 3).

Here Figure 3. Interaction between MIT and Visual-perceptive reasoning (PRI) in predicting MoCA



Finally, also the interaction between the cognitive domain of the working memory and the mental images on the MoCa reveals that Mental Imagery can produce a positive effect on working memory interaction when working memory has high positive scores. If the working memory is low the effect of mental images on cognitive disability is buffered (Figure 4).

Here Figure 4. Interaction between MIT and Working memory (WMI) in predicting MoCA



5. Discussion and conclusions

The present study aimed at examining, in adult subjects with ID, the relationships between cognitive functions (MoCA), components of intelligence (WAIS-IV) and the Mental Imagery (MIT).

The results show that the MoCA significantly correlates with MIT and with three out of four factors of the WAIS-IV, i.e. Verbal Comprehension, Visual Perceptual Reasoning and Working Memory. The same trend was found for the relationship between the MIT score and the cognitive domains of the WAIS-IV.

The confirmatory analyses suggested that, for evaluating the relationships between intelligence and Mental Imagery, the WAIS factors are to be preferred to the two grouping indices of General Ability and Cognitive Proficiency.

The results showing that imagery improves the effect of verbal comprehension factor in predicting the improvement of the MoCA results, confirm what claimed by Farah (1984, 1985), about the linguistic components of imagery. Imagining by means of “mental eyes or ear” implies the activation of visual and auditory cerebral areas; but also the verbal areas are activated, which are delegated to remember, to name, to classify linguistically and semantically the images.

As regards the stronger relationship between mental imagery and the cognitive domain of visual-perceptual reasoning, this result supports the neurobiological hypotheses that, at the level of cerebral functional organization, both perceptual and imagery skills are involved in processing, on a visual and auditory basis, both present or imagined stimuli (Kosslyn, 2005; Guillot & Collet, 2010).

Moreover, the relations of imagery with both the verbal and visual-perceptual components of intelligence (typical of crystallized intelligence), confirm the model claiming for the involvement of both perceptual and linguistic systems in determining the processing of images.

Also working memory is implicated in moderating the impact of mental imagery on the MoCa scores. In this regard, it should be recalled that the MIT test was constructed with the aim of maximizing the difference between imaginative and memory tests.

The results of our study may have applicative relevance for rehabilitation.

There is empirical evidence about the long-term positive effects of imaginative training in facilitating associative learning in ID (Zupnick & Meyer, 1975), improving performance both in response times (Suburg, 1991) and in motor performance (Surburg, Porretta, & Sutlive, 1995). Imaginative training, in conjunction with physical practice, improves the accuracy of performance and reduces its variability (Porretta & Surburg, 1995); its usefulness has been demonstrated in increasing cognitive abilities in atypical development (Czerwinsky Domenis, 1995; Joffe, Cain, & Marić, 2007).

A mental imagery training concerning the learning of prose pieces in a sample of children (aged 7-12 years) and adults (18-57 years) with Down syndrome, has proved to be effective for both ages: the improvement of the memory is superior than in the only auditory condition (De La Iglesia, Buceta, & Campos, 2005). Hemayattalab and Movahedi (2010) proved that imagery in integration with real physical training – widely used in the mental training of athletes - is also useful in ID.

Taking into account mental imagery in the assessment of the profile of cognitive abilities in ID and in planning the rehabilitative trainings, offers a possibility of enhancing the effectiveness of the interventions

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