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BRIEF REPORT

Updated Italian norms for the Paired-Associate Learning Test (PALT)

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Abstract

Background Verbal associative learning is a key component of episodic memory and is frequently impaired in the early phases of neurodegenerative brain disorders. The Paired-Associate Learning Test (PALT) test directly probes this function, and its clinical usefulness critically depends on the availability of contemporary, population-specific normative data.

Aims To provide updated, regression-based normative data for the Italian PALT.

Methods Participants ($N = 317$) were administered the PALT, consisting of eight semantically related and unrelated word pairs presented over three learning trials. Regression-based norms were derived in accordance with the Equivalent Score (ES) method.

Results Age and education significantly predicted PALT scores. Up-to-date demographic adjustments, tolerance limits, and ES threshold were provided.

Conclusions This work delivers updated, regression-based Italian norms for the PALT to be employed for the assessment of episodic memory in patients with neurodegenerative brain disorders.

Keywords Paired-Associate learning · Long-term memory · Normative data · Cognitive impairment · Neuropsychology · Psychometrics

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Introduction

Associative learning is a fundamental mechanism of episodic long-term memory functioning, involving the ability to remember relations between elements by binding multiple features of an experience into a coherent memory trace [1].These processes critically rely on the integrity of medial temporal structures, particularly the entorhinal region and the hippocampus which represent the earliest regions involved in memory decline during the prodromal stage of Alzheimer's disease [1–3]. The Paired-Associate Learning Test (PALT) is one of the most informative, second-level cognitive test for the assessment of episodic memory [4]. David Wechsler introduced the Paired Associates Test in the Wechsler Memory Scale establishing it a classic subtest for assessing verbal episodic memory [5]. In this paradigm, participants are presented with semantically related and/or unrelated pairs of words and then asked to recall one member of each pair when cued with the other [6, 4]. Since specifically evaluating verbal relational binding, the PALT has been highlighted to be more sensitive to

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medial temporal lobe involvement than tasks requiring the recall of single items or simple words lists [6]. Hence, the PALT is recommended for the assessment of memory skills in mild cognitive impairment (MCI) and dementia due to neurodegenerative conditions [2]. In Italy, three standardized versions of the PALT are currently available; however, all rely on normative data collected 30 to 40 years ago [6–8], which are unlikely to adequately reflect contemporary demographic characteristics [9]. Therefore, the aim of the present study is to provide updated normative data for the Italian PALT. Specifically, the present study focuses on the version including both semantically related and unrelated word pairs, adapted from Novelli et al. [6].

Methods

Participants

A total of 353 healthy participants from different regions of Italy (Lombardy, Trentino Alto-Adige, Lazio and Sicily) were recruited between 2021 and 2025. All participants were native Italian speakers with normal or corrected-to-normal vision and hearing. Exclusion criteria included: (1) uncorrected vision or hearing disorders, (2) history of neurological/psychiatric conditions, (3) current psychotropic medication use, (4) uncompensated metabolic or other severe medical conditions. In addition, participants were screened for sub-clinical cognitive deficits *via* the following, brief tests: Phonemic Fluency Test - Letter "F" [10] Semantic Verbal Fluency - "Animals" [10] and Backward Digit Span [11]. These tasks were selected since they assess executive functioning, semantic retrieval, and phonological working memory, domains sensitive to early cognitive decline and useful for distinguishing healthy individuals from those with neurodegenerative conditions [12]. A demographically adjusted, below-cutoff score on at least one of these tests was addressed as a further exclusion criterion, providing a conservative screening approach.

As a result, the sample comprised 317 participants (195 females; mean age: 62.79 ± 11.97 years, *range* = 40–89; mean education 13.17 ± 4.03 years, *range* = 5–23), whose stratification by age, education and sex according to Boccardi et al.'s [13] guidelines is reported in Supplementary Table 1.

Materials

Each participant was individually assessed by a trained examiner with the PALT – adapted from Novelli et al. [6]. Participants were presented with eight pairs of words, half of which were semantically related and half unrelated. The administration followed the procedure described by Novelli et al. [6]. : the examiner read each pair aloud at a rate of one word per second, with a one-second pause between pairs. After all pairs were presented, the examiner read the first word of each pair and asked the participant to recall the corresponding second word (i.e., cued recall task). This procedure was repeated across three learning trials, always using the same word pairs but varying the order of presentation and recall on each trial. For scoring, one point was assigned for each correctly recalled semantically unrelated pair and half a point for each correctly recalled semantically related pair, yielding a total score ranging from 0 to 18. The protocol for the present PALT is available upon request to the Corresponding Author.

Statistical analyses

In accordance with previous Italian normative studies [14], the minimum sample size for a multiple regression analysis was set at $N = 287$ using the R 3.6.3 package *pwr* [15]; this procedure addressed the following parameters: $\alpha = 0.05$; $1 - \beta = 0.90$; $f^2 = 0.05$; $df_{numerator} = 3$ (i.e., the number of possible predictors, namely age, education and sex).

In line with the Equivalent Score (ES) approach [16], raw scores (RS) were corrected for the effect of significant intervening predictors (or their transformations) by means of a regression-based equation. Specifically, the influence of demographic variables (i.e., age, education and sex) on test performance was first evaluated using multiple regression analyses. Then, significant predictors were used to generate equations for the demographically adjusted scores. The cut-off value was determined by computing non-parametric outer and inner tolerance limits (oTL; iTL). Finally, adjusted scores (AS) above the oTL but at or below the median (Mdn) are further divided into a 5-point, quasi-continuous standardized scale, defining ability levels based on *z*-scores: ES = 0 (AS ≤ oTL; "defective"); ES = 1, 2, and 3 (oTL < AS ≤ Mdn; "borderline," "low-end normal," and "normal," respectively); ES = 4 (AS > Mdn; "high-end normal").

All statistical analyses were performed using R 4.4 and jamovi 2.6 (https://www.jamovi.org).

Results

Participants' demographic and cognitive scores are summarized in Supplementary Table 2, whereas Supplementary Table 3 presents stratified means and standard deviations of PALT scores. The multiple regression model revealed natural logarithm-transformed age and non-transformed education as significantly predictors of the PALT (age: $b = -4.83$, $t = -4.99$, $p < .001$; education: $b = 0.27$, $t = 5.92$, $p < .001$);

Table 1 Adjustment equation and Equivalent Scores for the PALT

Adjustment equation						
AS = RS + 4.829518*(ln(*age*)-4.12185)-0.270868*(*education*-13.1735)						
		Equivalent Scores (ES)				
oTL	iTL	0	1	2	3	4
4.94	6.32	≤4.94	4.95–6.60	6.61–8.35	8.36–10.66	≥10.67

PALT = Paired-Associate Learning Test; AS = adjusted score; RS = raw score; oTL = outer tolerance limit; iTL = inner tolerance limit

no effect of sex was detected (p>.050). Table 1 reports the adjustment equation for the PALT, along with the oTL, the iTL and and ES thresholds. A spreadsheet for the automated computation of ASs and ES is provided in Supplementary Material 1.

Discussion

This study provides Italian users with updated normative data for the PALT, focusing on a version that includes both semantically related and unrelated word pairs [6]. The present norms were derived from a relatively large and demographically representative sample of healthy Italian adults (N=317) using a gold-standard, regression-based norming procedure [16]. Compared with previously available norms [6, 9, 10], they account for the demographic changes that have occurred in Italy over the past three to four decades.

In line with previous Italian normative studies [6, 9, 10], PALT scores were negatively associated with increasing age and lower educational attainment, underscoring the need to adjust test scores for these demographic confounders. Notably, the present study also included participants aged 80–89 years, representing a methodological refinement compared with previous normative samples for this test [6, 9, 10], in which the upper age limit was 70 years [9] or 79/80 years [6, 10].

Moreover, sex was not a significant predictor of PALT performance. While previous normative studies on similar tasks reported no sex effect [6, 8], longitudinal evidence has linked male sex to greater decline on the PALT in older hypertensive populations [17]. This discrepancy may reflect differences in study design (cross-sectional vs. longitudinal) and population characteristics.

An additional aspect of present version of the PALT concerns its brevity, as it includes fewer word pairs than previous Italian versions (8 vs. 10 [6]). This reduction was primarily intended to obtain a shorter form that may facilitate administration in time-restricted assessment contexts and in examinees prone to fatigue. It should be noted, however, that this item reduction was not based on a specific theoretical rationale but rather on pragmatic considerations aimed at improving test feasibility. Moreover, the present study focused on a specific version of the PALT and did not directly compare it with other episodic memory measures. Therefore, future studies should investigate its diagnostic properties and directly compare its clinical utility with that of other available versions and established episodic memory tests.

This study is not without limitations. First, the current version of the test relies on a single total score that aggregates semantically related and unrelated pairs, with reduced weighting assigned to semantically related pairs. Although this choice facilitates clinical usability, it precludes from a direct examination of potential dissociations between the two pair types – which has been shown to be diagnostically informative in the early stages of Alzheimer's disease [2]. Second, young individuals with low education and elderlies with high education were slightly under-represented in the normative sample. Finally, this study did not focus on the psychometric and diagnostic properties of the test – which should be systematically examined in future, dedicated investigations. A further limitation concerns the absence of a screening test for global cognitive functioning. However, recent normative studies have similarly relied on clinical and anamnestic criteria [18, 19]. Importantly, despite the lack of a global screener, a conservative approach was adopted by excluding participants showing a defective score on any of three independent cognitive tests. Finally, although the present study provides updated normative data, a dedicated clinimetric investigations are needed to evaluate the diagnostic accuracy and clinical utility of the PALT, as reliance on normative thresholds alone may limit the diagnostic contribution of neuropsychological tests [20].

To conclude, this work delivers updated, regression-based Italian norms for the PALT to be employed for the assessment of episodic memory in patients with neurodegenerative brain disorders.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40520-026-03388-2.

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Author contributions SZ: conceptualization, data collection, drafting, revision, resources; ENA, FF, GDL, BC, AM: formal analysis, drafting, revision; AC: data collection, revision; TD: data collection, revision; LR, AF, AT, EDR: revision; BP, NB: resources, revision; PC: conceptualization, drafting, revision, resources.

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Data availability Datasets associated with the present study cannot be made publicly available as including sensitive information but can be made available upon reasonable request of interested researchers to the Corresponding Author, who will forward a data transfer agreement request to the relevant Ethical Committees.

Declarations

Competing interests The authors declare no competing interests.

Ethical approval This study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Ethics Committee of IRCCS Istituto Auxologico Italiano (I.D.: 25C122).

Informed consent Participants provided written informed consent.

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