

Italian neuropsychology in the second half of the twentieth century

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Abstract Since the early 1960s, human neuropsychology, the study of brain-behavior interrelations, mainly based on the analysis of their pathological variations, brought about by brain damage, has had a remarkable systematical development in Italy. All this started in Milan, with the neurologist Ennio de Renzi, and his collaborators (Luigi Vignolo, then Anna Basso, Pietro Faglioni, Hans Spinnler, François Boller, and, more autonomously, Edoardo Bisiach), in the Clinic of Nervous and Mental Diseases. Scientists of the “Milan group” investigated several neuropsychological deficits caused by focal hemispheric lesions in large series of left- and right-brain-damaged patients, and control participants, comparable for cultural and demographic variables. Standardized tests and

advanced statistical methods were used, which also applied to the diagnosis and rehabilitation of aphasia. Subsequently, neuropsychology developed in Italy extensively, reaching high international reputation. Leading neuropsychologists have been the neurologists Guido Gainotti (Rome), and Franco Denes (Padua), the physicians and psychologists Luigi Pizzamiglio (Rome), and Carlo Umiltà (Parma, with fruitful interactions with the neurophysiologists Giovanni Berlucchi, Giacomo Rizzolatti, and Carlo Marzi, from the school of Giuseppe Moruzzi in Pisa) A second scientific generation of neuropsychologists has then developed in the 1970s, trained by the abovementioned scientists, further boosting and spreading high-level basic and applied research (diagnosis and rehabilitation of neuropsychological deficits of patients with brain damage or dysfunction throughout the life span, from childhood to the elderly). Available techniques include structural and functional imaging (CT, PET, SPET, MRI and fMRI Scans, DTI), electrophysiological recording (EEG, ERPs), non-invasive brain stimulation (TMS, tES), and their combined use.

This article is dedicated to the memory of Professor Ennio De Renzi (1924–2014) who passed away on November 9th. De Renzi’s research and teaching have made him a leading authority in the field, recognized as such not only in Italy, but also throughout the world. He has had a strong and highly beneficial influence on the professional lives of the authors of this review. Furthermore, it can be said that he positively affected the professional life and thinking of most of the persons mentioned in this article. In the last few months, Ennio discussed with us in depth many of the topics considered in this article. We are grateful to him also for this last contribution to Neuropsychology.

Keywords History · Ennio de Renzi · “Milan Group” · Neuropsychology · Neuroimaging · Brain stimulation

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Modern Italian neuropsychology: Ennio De Renzi and the “Milan group”

The foundation of the “Milan” group in the 1960s

In the period between the early 1800 and the 1960s, there were some significant, but sporadic, contributions [1], which never led to the foundation of a “school” [2]. The development of neuropsychology in Italy can be attributed without a doubt to Ennio De Renzi (1924–2014) [3], the founder of the “Milan group”, and of the Italian neuropsychological school. In the Clinic of Mental and Nervous Diseases of the University of Milan, De Renzi investigated a large number of brain-damaged patients with focal stroke and neoplastic lesions, collaborating with several younger clinical neurologists, first and foremost Luigi A. Vignolo (1934–2010), who had spent time in the Service of the neurologist Theophile Alajouanine at the Salpêtrière in Paris, working on aphasia. At the same time, Anna Basso [4] attended the Service of Language Rehabilitation organized by Madame Blanche Ducarne de Ribaucourt also at the Salpêtrière; Basso set up and directed the first Service for the Rehabilitation of Aphasia, and a School for speech therapists, which rapidly became a standard model in the field. In 1962, De Renzi and Vignolo published in “Brain” [5] an article—which can be considered the first modern neuropsychological study coming from Italy in an international journal—reporting a test (the Token Test), aimed at assessing auditory comprehension in aphasia.

De Renzi established the experimental methodology of the group: the approach was mainly based on the quantitative assessment of the cognitive ability of interest in patients with left and right hemispheric brain damage, and neurologically unimpaired participants (controls), by means of ad hoc devised and standard tests, and the successive statistical comparison of the patients’ and controls’ performances, taking into account, and partialling out, the influence of sex, age, and education. The neurologist Pietro Faglioni was the main developer of these advanced statistical methods.

The North American psychologist Arthur Benton (1909–2006) played an important role in shaping the research approach and methods of the group: in 1964, he held a 2-month course in Milan. The translation of Benton’s lectures by De Renzi and Vignolo [6] was the first textbook on neuropsychology published in Italy, and played an important role in spreading this culture among neurologists and psychologists.

The main research topic of the group concerned hemispheric differences in higher order mental processes. Two sets of results may be mentioned: the greater and more frequent impairment of spatial abilities consequent to right than to left hemispheric damage; different patterns of

impairment after unilateral hemispheric damage in stimulus recognition: the right hemisphere proved to be more involved in the perceptual discrimination of the stimulus’ qualities, the left one in its identification (“recognition”, with retrieval of its semantic associations). This hemispheric asymmetry held for visual material, but also involved color processing, and auditory stimuli [1, 3].

The development of Italian neuropsychology in the 1960s took also advantage of the participation of De Renzi, Vignolo, and other neurologists from Milan in the 1964 International Neuropsychology Symposium, in San Gimignano, Italy [7]: it marked the beginning of a period of work and relationships of personal friendship with neurologists and psychologists from various European countries (Fig. 1). This contributed to give an international perspective to the group, and, more generally, to Italian neuropsychologists, who started to be known outside of Italy.

This international network of scientific relationships included most main investigators concerned with human neuropsychology, i.e., mainly interested in the effects of brain damage on higher order mental functions in humans. Different perspectives were represented, including clinical neurology (e.g., Norman Geschwind, Marcel Kinsbourne, John Oxbury, Klaus Poeck), and psychology (e.g., Elizabeth Warrington, Brenda Milner, Hans-Lukas Teuber), but also students of the effects of brain damage in both animals and humans (e.g., George Ettliger, Josephine Semmes).

In the 60s, the Milan group grew, including a number of neurologists, who were to play an important role in later years, in Italy and abroad. François Boller, who left the group in the middle 1960s, to move to the US, worked mainly on neurodegenerative disorders and dementia, and has been, between the 1980s and the 2000s, together with Jordan Grafman, the editor of the Handbook of neuropsychology, a monumental compendium of the discipline. Hans Spinnler, born in Basel, Switzerland, due to his mastering of the German language, was able to read the classical neuropsychological literature from the Austro-Hungarian Empire and Germany, making it available to the group; he later developed new paths in the field of memory and dementia, which was becoming a more and more relevant medical and social emergency [1]. With them, De Renzi and Vignolo published work dealing with different themes, but all attempting to clarify various aspects of brain-behavior relationships: reaction times in patients with left and right brain damage, deficits of spatial orientation, abstract thinking, hemispheric differences in visual memory; the sensitivity of the Token Test to detect minor (“latent”) aphasic deficits in left-brain-damaged patients [1, 3].

Edoardo Bisiach, who had a largely autonomous and original approach, in the early 1960s went to Moscow,

Fig. 1 Participants in the Symposium of the International Neuropsychological Society (INS), that took place in S. Gimignano, Siena, Italy. *1st row from left* (1–6) Ennio De Renzi, Brenda Milner, Martha Wilson, Hans-Lukas Teuber, Henry Hécaen, Carlo Gentili; *2nd row* (7–11) Edoardo Bisiach, C. Faust, M^{me} I. Gloning, Elizabeth K. Warrington, Marcel Kinsbourne. *3rd row* (12–18) Pietro Faglioni, Hans Hoff, F.G. von Stockert, Josephine Semmes, Norman Geschwind, Klaus Poeck, Colwyn Trevarthen. *4th row* (19–21) Hans Spinnler, R. Quatember, Luigi A. Vignolo. *5th row* (22–25) François Boller, George Ettingler, Sue and John Oxbury



where he attended the Institute of Psychology directed by Alexander R. Luria, whose work was made available to the Italian public, thanks to Bisiach's translation from Russian of *Higher Cortical Functions in Man* [8]. Bisiach's main achievement concerned disorders of higher order visuo-spatial functions in right-brain-damaged patients, culminating in his work on unilateral spatial neglect, and anosognosia, conceived as deficits of conscious spatial representations [9].

Cortex

We owe to Ennio De Renzi another very relevant initiative, which established neuropsychology in Italy as an internationally relevant discipline. This was the launch in 1964 of an international journal, *Cortex* (Fig. 2), described as "...devoted to the study of the interrelations of the nervous system and behavior, particularly as these are reflected in the effects of brain lesions on mental functions". The editorial board was composed of international eminent scientists: from continental Europe, the neuropsychiatrist Julian de Ajuriaguerra (Genève, Switzerland), the neurologists Eberhard Bay (Düsseldorf, Germany), and François Lhermitte, (Paris, France); from the UK, the neurologist Macdonald Critchley, and the

neuroscientist George Ettingler (London); from the US, the neurologists Robert J. Joynt (Rochester, NY), and Norman Geschwind (Boston, Mass., US), and the neuroscientist Josephine Semmes (New York); from the Soviet Union, the psychologist Alexander R. Luria (Moscow). Articles could be submitted in English, French, German, Italian, and Spanish, always with an abstract in English, in addition to the original language. To appreciate adequately the novelty of *Cortex*, it should be considered that, at that time, all neurological journals published in Italy [e.g., *Rivista di Patologia Nervosa e Mentale*, *Sistema Nervoso*, *Rivista di Neurologia*, *Acta Neurologica (Napoli)*] were written in Italian. The first neurological journal written in English was launched in 1980: *The Italian Journal of Neurological Sciences*, then, since 2000, *Neurological Sciences*, the official journal of the Italian Neurological Society. The origins and the development of *Cortex*, as well as its success, have been recently reviewed [1, 3, 10]. On the basis of bibliometrics, *Cortex*, now published by Elsevier, and whose current Editors are Sergio Della Sala and Jordan Grafman, was named in 2010 a "raising star" in the field of Neuroscience and Behavior by Thomson Reuters: (<http://archive.sciencewatch.com/inter/jou/2010/10oct/Cortex/>). (Table 1)

Table 1 History of Italian clinical human neuropsychology

Period	Methods framework/models	Theoretical	Topics	International impact NP societies
1850–1960				
See [1]	Qualitative clinical observation, single-case positive Pts, no statistics	Most frequently absent, classical Wernicke–Lichtheim–Charcot (box-and-arrows)	Agnosia, aphasia, frontal lobe syndrome (monkey), amnesia	Non-systematic studies, no international impact, possible exception frontal lobe (but in the animal)
1960–1970 Milan group				
E. De Renzi, L. A. Vignolo, A. Basso, E. Bisiach, F. Boller, P. Faglioni, H. Spinnler	Controlled selection positive/negative Pts (lesion side LH/RH, site A/P). Socio-demographic factors (age, education), neurological severity controlled by statistical partialling out (parametric analyses ANOVA, ANCOVA). Mainly large series of Pts, few single-case “positive” Pts. No adequate in vivo brain imaging	Behaviorism 1800s classical German neurological literature (as above, and Lissauer, Pick)	Aphasia, defective perceptual discrimination/ recognition (color, face, object agnosia), apraxia, defective spatial exploration-cognition (RH damage)	Systematic studies. Italian NP known internationally
1970–1980 new groups				
G. Gainotti, L. Pizzamiglio, G. F. Denes (Rome, Padua), C. A. Umiltà (Parma, Padua), C. A. Marzi (Verona)	As above by mid-1970s adequate brain imaging in vivo (CAT).	As above	As above, aphasia, rehabilitation anatomo-clinical correlations in vivo, laterality of emotions, assessment of mental deterioration in Pts with non-focal damage	As above, high international reputation, NP section Italian Neurological Society (Società Italiana di Neurologia, SIN)
1980–2000				
Second generation Milan, Rome, Bologna, Naples	Single-case vs. group studies, NP syndromes, better imaging (CAT, MRI), functional imaging (SPET, PET, fMRI)	Cognitive NP (information processing, box-and-arrow models of mind, brain/not brain-related) computational and neural (connectionist) models	Spatial neglect rehabilitation, multimodal sensory processing, single-case and groups. Cognitive NP-framed more refined brain-behavior correlations	As above, Italian Neuropsychology Society (late 1990s) (Società Italiana di Neuropsicologia, SINP)

A/P anterior/posterior, *LH/RH* left/right hemisphere, *NP* neuropsychology, *Positive/negative* with/without symptoms/deficits, *Pts* patients

Giuseppe di Pellegrino [13], who worked on multisensory integration and extinction [14]. De Renzi retired in 1994, aged 70, succeeded by Faglioni, and then by Nichelli.

The psychologist Roberto Cubelli started research in Modena, working with Nichelli on spatial neglect. He has since continued studying on aspects of aphasia, such as the role of articulation in inner speech [15], and dysgraphia [16], and spatial neglect. Cubelli is currently Managing Editor of *Cortex*.

In the 1970s, a second generation of neurologists from Milan, formed by Vignolo, Spinnler and Bisiach, had started to emerge in the neuropsychological arena. Giuseppe Vallar, pupil of Bisiach and Spinnler, has been mainly concerned with the neural and behavioral aspects of the syndrome of unilateral spatial neglect [17], and deficits of short-term memory [18]. Claudio Luzzatti, after early work

with Bisiach on spatial neglect [9], has mainly worked on aphasia, from a psycholinguistic perspective [19]. Stefano Cappa, trained by Vignolo, has dealt with many neuropsychological topics, mainly on the neural correlates of various aspects of language and aphasia [20]; Cappa is the current President of the Federation of European National Societies of Neuropsychology. Daniela Perani, initially trained by Bisiach [21], used neuroimaging methods for investigating the neural underpinnings of cognitive functions [22]. Sergio Della Sala, trained by Spinnler, has been mainly interested in memory and its disorders, in dementia [23], and in the syndrome of spatial neglect [24]. Costanza Papagno, a pupil of Vignolo, has been mainly working on neuropsychological disorders of memory and language [25], and on neuropsychological deficits of neurosurgical patients [26]. The main research themes of Anna Berti, a

student of Bisiach, concern spatial neglect, anosognosia, and consciousness [27]. Gabriella Bottini, a student of Vignolo, has made research on tactile recognition [28], neglect and higher order deficits of somatosensory processing [29].

Since the 1970s, the international relationships of Italian neuropsychologists were quite extensive. So, for example, Vallar, Della Sala and Papagno worked under the supervision of the English psychologist Alan Baddeley in Cambridge [23, 30], Berti of the English neurologist John Oxbury in Oxford [31], and Bottini of Richard S.J. Frackowiak in London [29]. The overall pattern is one of an impressive development of research, taking advantage of both up-to-date psychological models and methods [30], and novel imaging techniques, coupled with behavioral experiments [29].

Rome

The neurologist Guido Gainotti, who in the late 1960s and early 1970s had worked on the effects of unilateral lesions on emotional behavior [32], and with Ajuriaguerra and Tissot in Geneva, Switzerland, on unilateral spatial neglect [33], organized a Neuropsychology Service in the Policlinico A. Gemelli of the Catholic University in Rome. In the following years, Carlo Caltagirone, Gabriele Miceli, Paolo Bartolomeo, Maria Caterina Silveri, Antonio Daniele, Camillo Marra, Sergio Carlomagno, Roberto Arena, and Claudio Villardita were trained there [1]. Main research themes included semantic-lexical disorders in aphasia, and the anatomical correlates of category-specific semantic disorders [34], spatial neglect as a deficit of the automatic lateral orienting of spatial attention [35], some neuropsychological aspects of dementia [36], post-stroke depression [37]. Caltagirone subsequently moved to the University of Tor Vergata, and the Santa Lucia Clinic, both in Rome, where he organized, with the neurologist Giovanni A. Carlesimo, a group on the neuropsychological assessment of dementia [38], and memory disorders in brain-damaged patients [39]. Miceli, after a two-year period in the late 1970s, spent in Boston (Mass., USA) with Harold Goodglass [40], performed research in the field of cognitive neuropsychology and neurolinguistics, collaborating with Alfonso Caramazza [41]. Bartolomeo moved to Paris, where he set up a group investigating the neural bases of high-level visual abilities (attention, perception, reading, visual mental imagery), and their deficits after brain lesions. A main focus of research has been on the mechanisms and neural bases of visual neglect [42].

Luigi Pizzamiglio had obtained his Medical Doctorate in Milan in 1963, with Vignolo, and had specialized in Psychology in the Catholic University in Milan. Following a stay in the US (Columbus, OH), he continued research in

Rome, in the Department of Psychology of the State University “La Sapienza”. Relevant in these early years was his psycholinguistic and neuropsychological work on disorders of syntactic comprehension in aphasia [43]. Pizzamiglio made research in the field of neuropsychological rehabilitation, together with a team of psychologists trained by him since the late 1970s: Pier Luigi Zoccolotti, Gabriella Antonucci, Cecilia Guariglia. In later years, the group expanded to include the psychologists Fabrizio Doricchi, and Donatella Spinelli. Pizzamiglio organized a research center based on neuropsychological rehabilitation at the Santa Lucia Clinic, in which a variety of clinical and experimental methodologies for evaluating and treating cognitive disturbances (unilateral spatial neglect, attention and navigational deficits) were developed [44]. Furthermore, a wide range of studies were carried out, including: facial expression and recognition of emotions [45]; aspects of the syndrome of left spatial neglect in right-brain-damaged patients, such as its representational components [46], the effects of a variety of sensory stimulations [47], and some electrophysiological, psychophysical and eye-movement correlates [48].

Padua

In Padua, the neurologist Franco Denes, after a period of research spent in Boston with Harold Goodglass in the early 70s [49], founded a group mainly interested in the cognitive neuropsychology of language and calculation. The Padua group included the physician and psychiatrist Carlo Semenza, the neurologist Gianfranco Dalla Barba, the psychologists Patrizia Bisiacchi, and, later, Lisa Cipolotti. Semenza, who had also worked under the supervision of Goodglass in Boston in the early 1980s [50], worked on bodily representations [51], and the localization of body parts and their deficit (autotopagnosia). He also studied certain semantic categories, such as proper names [52]. Main research themes of this group also included: executive disorders, confabulation and amnesia, and their relationships investigated with a theory-driven approach [53], and semantic deficits [54]. Cipolotti, after training with Denes, moved to London, UK, and succeeded the eminent British clinical and cognitive neuropsychologist Elizabeth K. Warrington [55], at her retirement, as the Director of the Psychological Laboratory of the National Hospital for Nervous and Mental Diseases, Queen Square, London. Denes and Semenza have been organizing in Bressanone from 1983 onward an annual meeting (the European Workshop on Cognitive Neuropsychology), originally with a marked cognitive neuropsychological approach [56], and currently presenting a greater variety of perspectives. At the same time, in Padua, the psychologists Remo Job and Giuseppe Sartori, mainly influenced by the

cognitive scientist Max Coltheart, investigated language deficits of brain-damaged patients with a neurolinguistic approach [57].

Bologna and Parma

In Bologna, the psychologist Elisabetta Làdavas, a pupil of Carlo A. Umiltà (a physician, professor of Psychology in Parma), has investigated various aspects of hemi-inattention, and the different components of the space surrounding the body. Làdavas has formed a number of psychologists, including Alessandro Farnè and Francesco Pavani [58]. A notable characteristic of the work of this group has been the development of research paradigms in brain-damaged patients, largely based on neurophysiological experiments, and animal models. This has proved to be productive for investigating the relationships between multisensory integration and spatial reference frames. The group also first utilized a prism adaptation paradigm for rehabilitating left spatial neglect in right-brain-damaged patients, a currently extensively used procedure [59].

The neurologist Anna Mazzucchi, after having made research on a variety of issues, including agrammatism [40], became more focused on neuropsychological rehabilitation of brain-injured patients.

Trieste

The Scuola Internazionale per Studi Avanzati (SISSA, an International School for Advanced Studies) in Trieste has a neuroscience component. Tim Shallice, a British cognitive neuroscientist and neuropsychologist, has been at the SISSA since the mid-1990s, boosting research in the field. Of note is the work of the psychologist Raffaella Rumiati on apraxia [60, 61].

Naples and Sicily

Between '75 and '76, in Milan, Spinnler trained the neurologist Dario Grossi, who became acquainted with the methods of the “Milan group”, and made contact with other Italian neuropsychologists. In 1976, Grossi established a neuropsychology laboratory in the Neurological Clinic in Naples; with the help of the psychologist Arturo Orsini, he investigated the pattern of impairment of patients with dementia and visual-spatial deficits [62]. This was the first neuropsychology laboratory in Southern Italy where many young neurologists, particularly Luigi Trojano, were trained. The activity of the Naples' group spanned from normative data on neuropsychological tests [63], experimental investigations of neuropsychological deficits such as constructional and visuo-spatial disorders [62]. In Naples, the neurologist Sergio Carlomagno, who

had worked in Rome with Gainotti, and in Brussels with Xavier Seron, developed techniques for the rehabilitation of language disorders with a pragmatic approach [64].

In Sicily, after early work by the neurologist Claudio Villardita and his co-workers [65] in the Department of Neurology of the University of Catania, neuropsychological research has mainly developed in Palermo, with the neurologists Brigida Fierro, Filippo Brighina, and Massimiliano Oliveri [66].

Neurophysiology and neuropsychology: Pisa, Parma, and Verona

Some neurophysiologists, with a medical education, who had started their research and academic career in Pisa, under the supervision of the neurophysiologist Giuseppe Moruzzi, were interested in neuropsychological studies in brain-damaged patients. The neurophysiological research of Giovanni Berlucchi, Giacomo Rizzolatti, and Carlo A. Marzi in the animal (cat, monkey) is outside the aims of this chapter. As for neuropsychology, they investigated, together with Carlo Umiltà, functional hemispheric asymmetries and specialization in healthy participants using divided (left/right) half-field presentation of the stimulus and lateral (left/right) manual responses [67]. Studies in patients with focal brain damage concerned unilateral spatial neglect [68], blind-sight [69], and disorders of bodily representations [70]. Berlucchi, from 1995 to 1999 served as Editor-in-chief of the Journal *Neuropsychologia* (founded by Henry Hécaen in 1963), of which *Cortex* (founded in 1964) was a possible competitor in the early 1960s, when both journals were launched. The neurologist Salvatore M. Aglioti, trained by Berlucchi, extensively worked on body representations and their neuropsychological disorders, including delusional disownership of body parts, and the role of spatial processes in somatosensory awareness [70].

The main themes and issues of Italian neuropsychological research across 40 years: 1960–2000

The behavioral investigation of neuropsychological deficit and their neural underpinnings: anatomo-clinical correlations

When De Renzi started neuropsychological research in Milan, the possibility to perform correlations between the patterns of behavioral impairment in humans and their neural underpinnings was limited. Accordingly, in its early work, the “Milan group” confined the anatomo-clinical correlation to the side of the lesion, and its anterior–

posterior putative location, based on the absence/presence of visual half-field deficits. Since the 1970s, new neuroimaging tools allowed to visualize the brain and cerebral lesions in a more and more anatomically precise and detailed way, and, importantly, much less invasive for the patient than methods such as pneumoencephalography, and angiography, which, in addition, provided only an indirect image of the brain and the lesion of interest. These included first computerized axial tomography (CAT), and, a few years later, Magnetic Resonance Imaging (MRI), primarily used for the localization (site and size) of a brain lesion, and etiological diagnosis (most frequently stroke, and brain tumors). In the 1970s, standard lesion mapping methods were developed in Milan, primarily by Vignolo, and by Luzzatti, and Giuseppe Scotti. This benefited from Scotti's expertise: a neurologist involved at the beginning of his career in neuropsychological research, Scotti subsequently became a neuroradiologist, with a particular interest in neuroimaging for clinical purposes. The availability of in vivo imaging data, concerning the localization and size of the lesion in large series of brain-damaged patients with a given neuropsychological deficit of interest, made it possible to gather evidence on the neural underpinnings of the "classical" (with reference to the Wernicke–Lichtheim model) aphasic syndromes. In a few years, the lesion correlates of other neuropsychological deficits, such as unilateral spatial neglect, and limb apraxia, were investigated in large series of patients. The role of damage not only to cortical areas, and their white matter fiber connections (traditionally associated with neuropsychological deficits), but also to gray nuclei (mainly, thalamus, basal ganglia) was explored. The successive availability of functional neuroimaging techniques (Single Photon, and Positron Emission Tomography, SPET and PET, the latter with a greater anatomical resolution), associated with CAT, and later MRI, DTI (diffusion Tensor Imaging), and f(functional)MRI, allowed to further explore the neurofunctional correlates of aphasia, neglect, and their recovery [1].

The methodological debate and applied neuropsychology: diagnosis and rehabilitation

The debate on the methods of neuropsychological research

The early 1980s featured a lively debate on the then controversial methods of neuropsychology, which sometimes reached high levels of polemics: critical issues were the pros and cons (or, more drastically, the legitimacy) of group vs. single-patient (single-case) studies, for investigating the functional (psychological), and the neural basis of higher level (cognitive) behavior, in the light of multi-componential models of the mind.

A reappraisal shows that Italian investigators performed both single-case and group neuropsychological studies, and the conclusion may be drawn that both types are legitimate, addressing different research questions [1]. Interestingly, while the approach of the "Milan school" is generally known as one devoted to group studies with large samples of patients, typically subdivided into left- and right-brain-damaged patients, with anterior vs. posterior lesions, De Renzi and coworkers, since the beginning of their work, studied and reported, when appropriate, also single-case studies [71], such as patients with rare and peculiar patterns of impairment. In line with this sensible approach, the journal *Brain* currently states in its "Instructions to authors": "... single case studies are not considered. More detailed studies of single cases may in rare instances be considered as Reports, only when they resolve definitively an important problem in the field or when the data lead to a significant conceptual advance. Studies of single cases that can be readily performed on groups of patients will not be considered." (http://www.oxfordjournals.org/our_journals/brainj/for_authors/general.html).

The putative, and at that time, controversial patterns of impairment characterizing "short-term memory", "deep dyslexia", and "surface dyslexia", gave the opportunity to discuss the value of neuropsychological syndromes [72], both with reference to models of normal psychological functions, and their circumscribed neural correlates, and of the single-patient vs. group studies methodologies. It may be noted that supporters of the single-case approach, who emphasized the difficulty, if not the actual impossibility, of drawing definite and sound inferences as to brain-behavior relationships, on the basis of studies of brain-damaged patients, had been mainly concerned with investigating language deficits, with reference to multi-componential, very complex and detailed, models of language [73].

Neuropsychological rehabilitation

This area of applied research had been initially cultivated in Italy by Vignolo and Basso [4] for aphasic patients, with cultural instruments and methods largely based on the triad "group studies/quantitative tests/statistical analyses", in the context of the general behavioral approach set up by De Renzi in the early 1960s. Even these early investigations, however, had suggested some hints for a multi-componential organization of language, by and large in line with the single-case approach of cognitive neuropsychology [73]. The proliferation of this, so to say, "cognitive neuropsychology tendency" allowed for glimpses of the greater potential for application based on in-depth analysis and interpretation of the specific patterns of impairment of each individual patient. At present, in adult brain-damaged patients, neuropsychological rehabilitation, not only of

aphasia, but also of other disorders, mainly spatial neglect, started by Pizzamiglio, and then pursued by Làdavas, Vallar, and their coworkers, is well established in Italy, as witnessed by a Consensus Conference held in Siena in 2010 [74]. So far, in addition to the traditional and time-honored behavioral rehabilitation techniques, involving extensive training, the adjuvant contribution of electrical and magnetic non-invasive techniques is more and more used in neuropsychological rehabilitation [66, 75].

Conclusion

At the beginning of the twentieth century, the status of Italian neuropsychology is one of a fully developed discipline. Neuropsychology in Italy, on the one hand, has preserved the main original features of the “Milan group” (standardized tests, advanced statistical methods, able to take into account potential biasing factors, over and above the analysis of the patients’ performance, the importance of an appropriate control group), and, on the other hand, has exploited new relevant inputs, also from related fields (cognitive psychology, neuroimaging, electrophysiology). With rigorous assessment and statistical methods, both group, and single-patient studies have been performed, when appropriate [72, 73].

Looking backwards to the 1960s, there are chances that neuropsychology shall continue to flourish in Italy, in a more and more international dimension.

Conflict of interest The authors declare that they have no conflict of interest.

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