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Top Geriatr Rehabil. Author manuscript; available in PMC 2014 October 27.

Published in final edited form as:
Top Geriatr Rehabil. 2014 ; 30(1): 18–34. doi:10.1097/TGR.0000000000000001.

Communication Difficulty and Relevant Interventions in Mild Cognitive Impairment: Implications for Neuroplasticity

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Abstract

Mild Cognitive Impairment (MCI) represents a critical point for controlling cognitive decline. Patterns of communication difficulty have been observed in patients with MCI and warrant examination and management. The present systematic review examined (1) characteristics of communication difficulty in MCI by focusing on two domains: expressive and receptive communication, and (2) cognitive interventions that addressed communication difficulties in individuals with MCI. Of the 28 observational studies we reviewed, expressive and receptive communications were generally impaired in individuals with MCI, compared to their healthy counterparts. However, only one of seven interventions effectively improved communication related outcomes. We finished the paper with a discussion about how neuroplasticity influences communication abilities in individuals with MCI to inform the future development of interventions for communication difficulty.

Keywords

Communication difficulty; Mild Cognitive Impairment; Cognitive intervention; Compensatory Scaffolding; Neuroplasticity

Introduction

Mild cognitive impairment (MCI), a heterogeneous disorder of older adults characterized by mild cognitive decline, is often a prodromal phase of Alzheimer's disease (AD) and other dementias.[1] Clinically, individuals with MCI may complain of subjective cognitive concerns, and will demonstrate objective evidence of cognitive impairment (1–1.5 SD below the mean for age- and education-matched peers) that cannot be accounted for by normal aging processes. They do not yet exhibit impairment in their ability to perform basic activities of daily living (BADLs), while instrumental ADLs may or may not be impaired.[1, 2] There are four clinical subtypes of MCI. In amnestic MCI (aMCI), the individual experiences memory impairment; in nonamnestic MCI (naMCI), memory is

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unimpaired, but deficits are seen in other cognitive domains such as executive functions, visual-spatial skills and/or language.[3] Each of these subtypes is then further divided into single or multiple domain categories, depending on whether one or more cognitive skills are affected.[1]

MCI represents a critical point for controlling cognitive decline, and an important target for secondary prevention techniques aimed at slowing further progression to dementia.[4, 5] Of note, most available interventions in MCI have targeted memory.[4, 6] However, patterns of communication difficulty have also been observed in patients with MCI and warrant examination and, potentially, management. Communication difficulty refers to deficits in receiving, sending, processing, or comprehending verbal, nonverbal or graphic messages-, and is an important domain for everyday functioning.[7] In one study of heart failure patients, communication impairments were found to significantly predict adherence to treatment guidelines.[8] Additionally, in a study of over 12,000 Medicare beneficiaries, those with communication impairments were found to be significantly more dissatisfied with the health care they received than those without such impairments.[9] From these studies, one can infer that communication difficulty may serve a similar role in predicting health care quality and satisfaction in MCI, although research specific to MCI in this regard is limited.

Relatively brief clinical visits to medical providers require patients to efficiently organize, articulate and understand complex medical discussions and choices in order to make treatment decisions that adequately reflect their care goals and values. While still usually deemed capable of making such decisions, patients with MCI have been shown to score significantly lower on measures of “understanding, appreciation, and reasoning” as compared to cognitively normal peers.[10] For example, a study examined older adults’ response to information about fictitious medications, and found that those with MCI were more responsive to the way the information was framed than were their healthy counterparts. Specifically, when positive information was conveyed using positive wording, or negative information with negative wording, those with MCI judged the sham medications similarly to healthy counterparts. However, when positive information was framed using negative wording, or negative information with positive wording, adults with MCI were more influenced by the way the information was framed than were the healthy elders, responding more to the tone of the message than the information itself.[11] This suggests that how information is expressed when delivering it to cognitively impaired adults is critically important and may influence their health care decisions. Therefore, for health care providers, understanding the communication profiles of people with MCI can help ensure that they receive comprehensible diagnostic information, fully understand their medical care options, and make well-considered treatment decisions, according to their personal goals of care.

To our knowledge, there has been only a single topic that included communication deficits in older adults with mild cognitive impairment.[12] The present systematic review focused exclusively on studies of participants with MCI, identified using standard diagnostic criteria,[1] excluding studies of subjects with dementia (unless included as a comparison group to MCI participants). Communication relies on multiple dimensions of cognitive abilities, including executive function (verbal fluency), memory (semantic memory), as well

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as language. Communication difficulties described in this review were classified into expressive and receptive domains.[7] Expressive communication refers to the output of communicative messages, or the use or production of language, and includes verbal fluency (semantic fluency and phonemic fluency), semantic memory (especially word retrieval and access to semantic knowledge), and expressive discourse. Studies examining motor speech production (strength, speed, control and agility of the speech mechanisms including the lips, tongue, larynx, etc.) were also included with the expressive communication studies, due to their focus on communication output. Receptive communication refers to understanding of messages, and encompasses sentence comprehension, receptive discourse, and reading comprehension. We also reviewed cognitive interventions that targeted outcomes related to communication deficits. Of note, almost all such interventions are cognition driven. We are aware of one study targeting communication deficits using physical exercise as the intervention,[13] which was not included in this review, but was described in the discussion. We finished this paper with a discussion about how neuroplasticity influences communication abilities in patients with MCI and by making recommendations for future research directions in this area.

Methods

Literature Review

For this systematic review, the literature search was filtered by age (65 years or older) and by English language. Studies examining samples that were not specifically identified as having any subtypes of MCI based on Peterson's criteria (2009) described above were excluded. Reference lists of relevant studies provided additional sources for this review. Studies with publication dates prior to 1999 were excluded as the MCI criteria were not yet fully validated.[14] Two searches were conducted in PubMed. The first search was conducted for observational studies, using terms "mild cognitive impairment" in combination with "communication disorders" (109 citations), "aphasia" (37 citations) or "discourse" (2 citations). The second search was conducted for cognitive intervention studies that targeted communication outcomes, using the terms "mild cognitive impairment", "Alzheimer's disease", "cognitive therapy", "cognitive intervention", "cognitive training", and "communication". Various combinations of these terms yielded 160 articles. Two researchers (M. J. and F. L.) independently examined the relevant papers. Information about the study design and findings related to communication difficulties are presented in Table 1 (observational studies) and Table 2 (intervention studies).

Results

Observational studies

A total of 29 observational (25 cross-sectional and 4 longitudinal) studies described the communication difficulties in MCI (see Table 1).

Expressive communication impairments

Verbal fluency—Verbal fluency tasks can be subdivided into three types: semantic fluency (generating items in a category), phonemic fluency (generating items beginning with

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a specific letter), and verb fluency (generating as many verbs as possible).[15] Verbal fluency tasks are generally measured as the number of items elicited within a time limit (e.g., one minute). Sixteen cross-sectional studies consistently found that individuals with MCI had significantly worse performance in verbal fluency compared to their healthy counterparts.[11, 16–28] Specifically, the patterns of verbal fluency deficits in individuals with MCI included production of fewer subcategories, and fewer items within those categories, compared to healthy counterparts.[24] Six studies demonstrated better verbal fluency performance by those with MCI than those with AD. [23, 25, 27–30]

Several factors influenced the verbal fluency performance in MCI, including the specific category or letter being assessed, the subtype of MCI, and level of education. In one study, subjects with MCI were able to name more animals than words beginning with the letter "F", but fewer vegetables than words beginning with the letter "S".[17] By combining results across three phonemic and two semantic fluency tasks, Brandt and Manning (2009) found that participants with single-domain aMCI performed similarly to healthy counterparts, with no discrepancy between semantic and phonemic tasks, while participants with multiple-domain MCI performed similar to those with AD, with more difficulty with the semantic fluency than phonemic fluency tasks. In addition, level of education affected scores on semantic fluency tasks more than on lexical fluency in Japanese subjects with MCI.[30]

Only one longitudinal study examined verbal fluency.[31]. The researchers assessed verbal fluency annually in individuals with MCI and found they were impaired relative to healthy counterparts on semantic fluency tasks from baseline throughout the ten year study period. In contrast, phonemic fluency was intact at baseline, but became impaired at year six.[31]

Semantic memory—Semantic memory refers to general knowledge, including factual information, the meanings of words and general information,[32] and is often measured by tests of word retrieval or naming of objects, but also includes tests of naming of proper nouns, , synonyms, word associations, similarities, and definition-word matching, among others. A total of 17 cross-sectional studies examined semantic memory in individuals with MCI, 12 of which found impairments relative to healthy counterparts. [11, 16, 18, 19, 27, 28, 33–39] However, three studies found no difference between participants with MCI and healthy counterparts on semantic memory tasks.[25, 26, 31, 40, 41] Seven studies showed significantly better performance for participants with MCI than for those with AD, [11, 16, 18, 25, 27, 28, 34] while two demonstrated no difference between MCI and AD groups on semantic memory.[19, 37]

The specific task demands of the measures influenced the performance on semantic memory tests in individuals with MCI. Participants with aMCI scored comparably to healthy counterparts on the Boston Naming Test, although when spontaneous naming was examined (i.e., no semantic or phonemic cues provided), the participants with aMCI scored lower than the healthy counterparts, but superior to those with mild AD.[16] Additionally, on a three part assessment of semantic memory including naming famous buildings, celebrity faces, and objects, participants with MCI named significantly fewer items on each test than the healthy counterparts. Further, 13% of the healthy counterparts were impaired on all tests, whereas 87% of subjects with MCI were impaired on at least one of the tests. Both groups of

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participants named fewer proper nouns (faces and buildings) than objects. The combination of the three tasks correctly predicted group membership 78.1% of the time for those with MCI and 100% of the time for the healthy counterparts.[42] Finally, intentional access to semantic memory (word retrieval) was found to be impaired in adults with MCI relative to the healthy counterparts, but automatic access (e.g., deciding whether items were words or non-words) remained intact; both intentional and automatic access were impaired in participants with AD, compared to those with MCI.[34]

Three longitudinal studies examined semantic memory over time in individuals with MCI.[31, 38, 39] In two of them, semantic memory was significant predictor of progression from MCI to AD.[38, 39] The third study did not find any significant difference between the participants with MCI and the healthy counterparts in semantic memory, on measures of word retrieval or semantic associations.[31]

Expressive discourse—A total of seven cross-sectional studies examined expressive discourse. Discourse, also called connected language, can be thought of as a, “window into the flow or misflow of information that may occur … as the speaker translates his or her thoughts into language”.[43] Measurements of expressive discourse in this review included picture description,[18] verbal descriptions of an imaginary trip,[36, 40] and story recall and inferencing.[28, 43–45] Of note, although story recall is often conceptualized as a measure of episodic memory ability, it was considered as a measure of discourse in this review, as story recall and inferencing appear to mirror the cognitive demands of daily discourse, including conversation, and are influenced by a person’s language abilities.[28] In addition, expressive discourse measures also encompass receptive discourse demands. That is, in order for a story to be accurately recalled and retold, it must have first been comprehended, synthesized and integrated by the participant. (See receptive discourse, below).

Expressive discourse ability was found to be impaired in individuals with MCI when compared to healthy counterparts in six studies, [28, 36, 40, 43, 45, 46] while one study found no difference between the two groups.[18] Four studies found that subjects with MCI performed better on story recall tasks than did those with AD.[18, 28, 43, 45]

In the only longitudinal study examining expressive discourse, Fleming and Harris found that there was no significant decline in expressive discourse skills between baseline and six months in eight participants with MCI.[35]

Motor Speech—Motor speech production skills were examined in two cross-sectional studies, measured by diadochokinetic (DDK) rate, a test of articulatory agility measured by rapid, successive repetitions of the syllables “pa ta ka”,[47] and by speed of sentence repetitions and vocal loudness.[29] Both studies found that motor speech remained largely unaffected in adults with MCI when compared to their healthy counterparts, and individuals with MCI performed significantly better than those with AD.[29, 47]

Receptive communication impairments have been less thoroughly studied than the expressive areas described above. Nevertheless, patterns of deficit have been found in subjects with MCI.

Sentence comprehension—Sentence comprehension refers to the understanding of single statements, and was assessed in only one longitudinal study, using the Token Test, Subtest V, a measure of comprehension of commands of increasing complexity. Their results showed that, of the 23% of the original sample who developed dementia after two years, 40% showed initial impairments on the Token Test.[39]

Receptive discourse—Receptive discourse refers to one's ability to comprehend connected narrative productions. As described above, this domain is difficult to fully separate from expressive discourse, as most tasks measuring discourse include both receptive and expressive components. In this review, two cross-sectional studies measured receptive discourse by eliciting recall and recognition of both gist and detail information from a narrative text.[28, 43] Adults with MCI showed poorer ability to recall and recognize details from a narrative story than did their healthy counterparts, but performed better than the subjects with AD on these tasks.

Reading comprehension—Three cross-sectional studies examined reading comprehension, which refers to the understanding of written narratives.[11, 44, 45] In one study, the subjects completed a reading comprehension test, and there were no significant differences between those with MCI, those with AD, and the healthy counterparts.[11] In the other two studies, subjects were required to read a text and then to verbally state the details and gist of the passage. In order to successfully accomplish this task, subjects needed to be able to understand what they had read.[44, 45] In both studies, subjects with MCI performed poorer on this task than the healthy counterparts did. In the study by Hudon and colleagues, participants with AD were also included, and performed significantly worse than those with MCI. [45]

Cognitive interventions with communication outcomes

Limited intervention studies have been conducted on communication outcomes in individuals with MCI. Seven cognitive intervention studies were identified (see Table 2).[48–54] Three studies utilized weekly small group sessions ranging from 90–120 minutes; the remaining four employed individual computerized cognitive training (CCT) sessions for 13–100 minutes per day, 4–5 days per week. Intervention durations ranged from three weeks to one year. Cognitive interventions were generally categorized into: memory, attention, processing speed, executive function-focused or multi-modal interventions.[55] Two studies were memory interventions. One study of 25 subjects with MCI and 17 healthy counterparts focused on memory strategy training,[56] and did not demonstrate improvement on story recall, a measure of receptive and expressive discourse, in either group. The other study targeted memory through education regarding memory, relaxation training, memory skills training and psychoeduction on structuring memory-related beliefs, but the intervention group (9 subjects with MCI) did not improve their receptive and expressive discourse (story recall) compared to the control group (10 subjects with MCI).[51]

Auditory processing speed and accuracy was targeted utilizing CCT in one study; no significant differences were found between treatment (22 subjects with MCI) and control

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(25 subjects without MCI) groups on measures of semantic memory and verbal fluency at post-intervention.[48]

The remaining four intervention studies applied multi-modal approaches, simultaneously targeting multiple cognitive domains.[50, 52–54] Wenisch et al. targeted memory, executive function, and visuospatial skills by teaching cognitive strategies, and demonstrated no significant change in the measure of verbal fluency in either the 12 subjects with MCI or the 12 healthy counterparts following the intervention.[54] Cipriani et al. utilized CCT for attention, memory, perception, visuospatial cognition, and language skills training, but did not elicit improvement on verbal fluency tasks in 10 subjects with MCI, although the 10 with AD did improve on the phonemic fluency task.[50] Talassi and colleagues combined CCT with occupational therapy and behavioral training (targeting "mood symptoms", p. 392), and found no statistically significant difference in the intervention groups (30 with MCI, 24 with mild dementia) on verbal fluency or discourse (story recall), as compared to the active control groups (7 with MCI, 5 with mild dementia).[53] Rozzini and colleagues examined the effects on subjects with MCI of CCT (addressing attention, memory, abstract reasoning, visuospatial skills and language) alone (n=22), as well as in combination with cholinesterase inhibitors (n=15), to a no treatment control group (n=22), and demonstrated significant improvement for the group receiving the combined intervention on story recall (receptive and expressive discourse), but not on verbal fluency measures. The CCT-only group and the control group did not show any significant improvements on either language measure.[52]

Discussion

The purpose of this systematic review was to examine observational and intervention studies addressing the communication characteristics of older adults with MCI by dividing the communication into expressive and receptive domains. Before further discussing any results, some limitations should be acknowledged. First, this systematic review was limited to a PubMed search only. Other databases that may contain studies related to communication difficulties (e.g., PsychInfo) were not reviewed. Second, communication is an everyday skill highly relying on multiple cognitive abilities, especially language, executive function, and semantic memory, and many of these cognitive abilities are highly interrelated, thus, some of the distinctions made here on the categories of communication may be somewhat artificial and incomplete.[28, 43] Third, communication difficulties in the clinical application may include psychosocial aspects. Communication is the "process of creating shared meaning" between a sender and a receiver, and includes all of their thoughts, perspectives, ideas, history and biases.[57] Examination of these psychosocial and interpersonal aspects of communication in older adults with MCI was beyond the scope of this review, but would be useful to incorporate into future studies, especially when designing interventions to address communication challenges in MCI.

Observational Studies

The first purpose of the study was to characterize the communication deficits of MCI in observational studies. First, motor speech production, representing a fundamental aspect of

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communication (i.e., the ability to produce the motor movements necessary to formulate intelligible speech) was largely unaffected in elders with MCI. Regarding higher-order cognitive domains that are related to communication, in general, individuals with MCI perform worse than their healthy counterparts, but better than those with AD in expressive communication within the domains of verbal fluency, semantic memory, and expressive discourse. However, there are several exceptions that warrant further exploration. First, individuals with MCI may perform differently even within the same communication domain, depending on the format of the measures. For example, although semantic and phonemic fluency tasks both test verbal fluency, individuals with MCI performed better on the former.[17] Similarly, although nine of the studies in this review utilized the Boston Naming Test to examine semantic memory, differences in performance were found when alternate tasks were used. In one study, adults with MCI were able to name common objects more easily than famous buildings and famous faces, suggesting that naming of proper nouns may have somewhat different neural underpinnings than naming of objects.[33] Second, individuals with multiple-domain MCI may have more impairment than those with single-domain MCI in expressive communication, at least in the domain of verbal fluency.[17] This finding adds support to the notion that communication is an everyday function relying on multiple cognitive abilities. Thus, individuals with multiple cognitive deficits, as seen in multiple-domain MCI, may experience greater communicative impairments. Third, although education is assumed to be one of the most consistent factor influencing cognitive abilities, its influence on the different communication domains and measures varies. For example, level of education was found to influence performance on semantic fluency, but not on phonemic fluency tasks.[30]

Of note, discourse may be a particularly rich area for differentiating the different levels of communication functioning between individuals with MCI and those with dementia or those without cognitive impairment. Discourse can be measured in a variety of ways and entails a complex interweaving of receptive and expressive language skills, as well as executive function, required for such tasks as planning narrative productions and generating inferences, among others.[43] Discourse is integral to human interaction, such as between medical providers and patients, thus, discourse may be a vital mechanism in understanding how communication difficulties impact the quality of medical care by examining MCI patients' interactions with health care providers.

Receptive communication characteristics of older adults with MCI have been less thoroughly described, although a few studies demonstrated impairments in individuals with MCI compared to their healthy counterparts in the areas of sentence comprehension, receptive discourse and reading comprehension. More studies, especially prospectively examining the degenerative process from normal aging, to MCI, to AD, are needed to lead to strong conclusions as to the distinguishing features of receptive communication in MCI.

Of note, the studies describe within this review do not represent all communication domains. For instance, no studies examined written communication in elders with MCI. Written description tasks of complex pictures were found to differentiate cognitively normal adults from those with probable AD.[58]

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Cognitive Intervention Studies

The second purpose of this review was to examine cognitive intervention studies with communication outcomes. As mentioned above, communication skills are interdependent on various domains of cognitive function, and all of the intervention studies reviewed here addressed communication by targeting different cognitive domains. Despite all that is known about communication impairments in MCI, and the current high degree of interest in cognitive training as a potential means for slowing cognitive decline in aging and MCI,[6, 55] only seven cognitive intervention studies were identified that included communication outcomes in the areas of verbal fluency, semantic memory, and expressive and receptive discourse. Of these studies, utilizing a variety of approaches, only one, incorporating a combination of cognitive training and pharmacological treatment, resulted in improvement in receptive and expressive discourse (story recall) in MCI participants.[52]

In addition to the small sample sizes (n=12 to 59 MCI participants), a major reason that may explain the lack of treatment effect in most of the reviewed intervention studies is that most of the interventions did not target domains of communication directly, or the transferring effect from the primarily targeted cognitive domain to communication related domains are not strong enough. The latter point is discussed below in the “neuroplasticity” section. Rozzini et al. was the only study that achieved a significant intervention effect in the MCI participants, and the only study directly targeting communication by including a language component within their computerized cognitive training intervention.[52] There have been studies conducted with other types of participants that are illustrative for future interventions in MCI. In one, expressive discourse measures were found to decline more slowly in patients with mild-moderate AD who received both pharmacological and eight weekly multi-modal communication treatment sessions comprised of education, communication strategies, and assistance in developing a “Life Stories Book”.[59] Additionally, in a study in which subjects received “lexical-semantic training” exercises in group setting twice per week for three months, improvements were seen in all communication measures (phonemic and semantic fluency, semantic memory, story recall) in participants with early stage probable AD, as compared to healthy counterparts.[60] These studies point to the potential for improvement in communication skills when they are specifically targeted in the intervention design.

Although only cognitive intervention studies were included in this review, there may be other types of behavioral interventions that may be beneficial for managing communication difficulties in MCI. One randomized controlled trial was located that utilized physical exercise (walking and hand and face exercises) and resulted in improvements in a measure of semantic fluency in participants with MCI.[13] Furthermore, in a quasi-experimental study examining the effects of a four year program that included volunteer work or other community activities, physical exercise, verbal fluency, and conversational stimulation treatment, four subjects with mild-moderate AD maintained or improved on a number of expressive discourse measures.[61] Other types of behavioral interventions, e.g., physical exercise, or a combination of different types of behavioral interventions warrant further exploration in individuals with MCI.

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Neuroplasticity

It is important to note that the observable, behavioral aspects of communication difficulties in MCI may be closely related to the structural and functional changes that are occurring within the brain. For example, one study demonstrated that both MCI and early AD participants were impaired in semantic memory, and both groups had cortical atrophy of the anterior temporal lobe and inferior prefrontal cortex.[37] In another study of a group of patients from very mild cognitive impairment to AD, the researchers found that impaired verb fluency was predicted by temporal lobe hypoperfusion (as assessed using single-photon emission computed tomography), while noun fluency was predicted by parietotemporal-occipital hypoperfusion.[62] In addition, de Zubicaray and colleagues demonstrated that a network including the left anterior temporal lobe, posterior temporal lobes, posterior inferior parietal lobes as well as two frontal lobe connective pathways were critical for semantic memory function in healthy older adults.[63] Thus, although the brain structure and function underlying the communication difficulties in MCI have not been fully explored, it is possible to surmise that they are influenced by a broad frontal-temporal-parietal network. Importantly, these brain regions are affected earliest in the neurodegenerative process.[64]

In applying behavioral interventions to improve communication functioning in patients with MCI, it is important to consider the potential mechanisms by which behavioral interventions may influence the development of neuroplastic alterations (i.e., changes of brain properties) that are related to the communication deficits. Neuroplastic changes occur within the brain as a result of interactions with the environment.[65] Accumulated studies with a focus on executive function have demonstrated that different types of behavioral interventions, especially cognitive training, induce measurable changes in structure and function (e.g., cerebral blood flow, glucose metabolism rate) of the brain regions that are closely related to targeted executive function in patients with MCI.[66, 67] It is unclear whether communication oriented behavioral interventions would induce similar neuroplastic changes.

Park and Reuter-Lorenz’s Scaffolding Theory of Aging and Cognition (STAC) may provide a theoretical framework for further understanding neuroplasticity and communication functioning in patients with MCI.[68] STAC proposes that compensatory scaffolding helps maintain high functioning behavior/cognition in the aging process. Compensatory scaffolding refers to the recruitment of additional neural circuitry to offset the brain structural and functional changes due to normal aging. The frontal lobe, especially the prefrontal cortex, plays an important role in the process of compensatory scaffolding. Communication skills are utilized continuously throughout the lifespan, therefore likely resulting in a robust and durable neural network.[68] However, as people age, these original networks, especially in the frontal-temporal-parietal region, break down, which results in the need for compensatory scaffolding mechanisms. For example, in one study, performance on a semantic memory test was compared between younger and older groups.[69] Using fMRI, the authors found increased activation of the inferior frontal cortex in the older group, even during the test with low difficulty level, as compared to the younger adults. Similarly, Meinzer and colleagues also observed increased activation of inferior frontal cortex across different difficulty levels of verbal fluency tasks in an older group, as compared to a younger group.[70]

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During the neurodegenerative process, as seen in MCI, the neural pathology (e.g., beta-amyloid accumulation in the frontal lobe) disrupts the protective function of the compensatory scaffolding. As hypothesized, cognitive training may provide a way to enhance or prevent the disruption of the compensatory scaffolding of the brain due to such pathological changes, especially during the early stage of decline, as seen in MCI. However, the current task is to find the most appropriate training program that can help with the scaffolding to compensate for the communication impairments seen in MCI. In a newly published study, healthy older adults demonstrated direct improvement in working memory, which is primarily controlled by the prefrontal cortex, following training of working memory. This training also effectively improved the untargeted communication-related domains of auditory and reading comprehension.[71] While not conducted with cognitively impaired adults, this study is supportive of the notion that cognitive training directly targeting prefrontal cortex may most effectively and directly enhance compensatory scaffolding, and ultimately, may affect other untargeted brain regions that are related to communication domains. As mentioned before, most of the intervention studies we reviewed did not directly target communication domains, but they did not target cognitive functions that are directly related to prefrontal cortex either. This may help explain why those studies failed to find any significant transfer effect from trained cognitive domains to untrained communication domains. Nevertheless, STAC may provide an entirely new pathway for developing cognitive interventions that may effectively address communication difficulties in individuals with MCI, through a potential transferring effect from the enhancement of the prefrontal cortex, where the compensatory scaffolding occurs, to the communication-related domains.

Conclusions

In summary, communication difficulty is an important component of the MCI profile that differentiates individuals with MCI from cognitively healthy elderly and patients with AD, and may therefore be a key target for intervention efforts designed to improve multiple domains of well-being in individuals with MCI.

Acknowledgments

The paper development was supported by the University of Rochester CTSA award number KL2 TR000095 from the National Center for Advancing Translational Sciences of the National Institutes of Health to Dr. Lin. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Petersen RC, Roberts RO, Knopman DS, Boeve BF, Geda YE, Ivnik RJ, Smith GE, Jack CR Jr. Mild cognitive impairment: Ten years later. Arch Neurol. Dec; 2009 66(12):1447–1455. [PubMed: 20008648]
2. Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, Fox NC, Gamst A, Holtzman DM, Jagust WJ, Petersen RC, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the national institute on aging-alzheimer's association workgroups on diagnostic guidelines for alzheimer's disease. Alzheimers Dement. May; 2011 7(3):270–279. [PubMed: 21514249]
3. Petersen RC. Mild cognitive impairment as a diagnostic entity. J Intern Med. Sep; 2004 256(3):183–194. [PubMed: 15324362]

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4. Mowszowski L, Batchelor J, Naismith SL. Early intervention for cognitive decline: Can cognitive training be used as a selective prevention technique? Int Psychogeriatr. Jun; 2010 22(4):537–548. [PubMed: 20170585]
5. Aisen PS, Petersen RC, Donohue MC, Gamst A, Raman R, Thomas RG, Walter S, Trojanowski JQ, Shaw LM, Beckett LA, et al. Clinical core of the alzheimer's disease neuroimaging initiative: Progress and plans. Alzheimers Dement. May; 2010 6(3):239–246. [PubMed: 20451872]
6. Gates NJ, Sachdev PS, Fiatarone Singh MA, Valenzuela M. Cognitive and memory training in adults at risk of dementia: A systematic review. BMC Geriatr. Sep 25.2011 11:55. 2318-11-55. [PubMed: 21942932]
7. American Speech-Language-Hearing Association. Definitions of communication disorders and variations. 1993; 2013 [relevant paper]. available from www.asha.org/policy. (05/31).
8. Alosco ML, Spitznagel MB, van Dulmen M, Raz N, Cohen R, Sweet LH, Colbert LH, Josephson R, Hughes J, Rosneck J, et al. Cognitive function and treatment adherence in older adults with heart failure. Psychosom Med. Nov-Dec;2012 74(9):965–973. [PubMed: 23115344]
9. Hoffman JM, Yorkston KM, Shumway-Cook A, Ciol MA, Dudgeon BJ, Chan L. Effect of communication disability on satisfaction with health care: A survey of Medicare beneficiaries. Am J Speech Lang Pathol. Aug; 2005 14(3):221–228. [PubMed: 16229673]
10. Appelbaum PS. Consent in impaired populations. Curr Neurol Neurosci Rep. Sep; 2010 10(5): 367–373. [PubMed: 20549394]
11. Zamarian L, Benke T, Buchler M, Wenter J, Delazer M. Information about medications may cause misunderstanding in older adults with cognitive impairment. J Neurol Sci. Nov 15; 2010 298(1–2): 46–51. [PubMed: 20864127]
12. Taler V, Phillips NA. Language performance in alzheimer's disease and mild cognitive impairment: A comparative review. J Clin Exp Neuropsychol. Jul; 2008 30(5):501–556. [PubMed: 18569251]
13. Scherder EJ, Van Paasschen J, Deijen JB, Van Der Knokke S, Orlebeke JF, Burgers I, Devriese PP, Swaab DF, Sergeant JA. Physical activity and executive functions in the elderly with mild cognitive impairment. Aging Ment Health. May; 2005 9(3):272–280. [PubMed: 16019281]
14. Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: Clinical characterization and outcome. Arch Neurol. Mar; 1999 56(3):303–308. [PubMed: 10190820]
15. Ostberg P, Fernaeus SE, Hellstrom K, Bogdanovic N, Wahlund LO. Impaired verb fluency: A sign of mild cognitive impairment. Brain Lang. Nov; 2005 95(2):273–279. [PubMed: 16246735]
16. Balthazar ML, Cendes F, Damasceno BP. Semantic error patterns on the Boston Naming Test in normal aging, amnestic mild cognitive impairment, and mild alzheimer's disease: Is there semantic disruption? Neuropsychology. Nov; 2008 22(6):703–709. [PubMed: 18999343]
17. Brandt J, Manning KJ. Patterns of word-list generation in mild cognitive impairment and alzheimer's disease. Clin Neuropsychol. Jul; 2009 23(5):870–879. [PubMed: 19301196]
18. Bschor T, Kuhl KP, Reischies FM. Spontaneous speech of patients with dementia of the Alzheimer type and mild cognitive impairment. Int Psychogeriatr. Sep; 2001 13(3):289–298. [PubMed: 11768376]
19. Carter SF, Caine D, Burns A, Herholz K, Lambon Ralph MA. Staging of the cognitive decline in alzheimer's disease: Insights from a detailed neuropsychological investigation of mild cognitive impairment and mild alzheimer's disease. Int J Geriatr Psychiatry. Apr; 2012 27(4):423–432. [PubMed: 21618285]
20. Economou A, Papageorgiou SG, Karageorgiou C, Vassilopoulos D. Nonepisodic memory deficits in amnestic MCI. Cogn Behav Neurol. Jun; 2007 20(2):99–106. [PubMed: 17558253]
21. Fernaeus SE, Ostberg P, Hellstrom A, Wahlund LO. Cut the coda: Early fluency intervals predict diagnoses. Cortex. Feb; 2008 44(2):161–169. [PubMed: 18387545]
22. Hall JR, Harvey M, Vo HT, O'Bryant SE. Performance on a measure of category fluency in cognitively impaired elderly. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. May; 2011 18(3):353–361. [PubMed: 21390875]

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23. Lonie JA, Herrmann LL, Tierney KM, Donaghey C, O'Carroll R, Lee A, Ebmeier KP. Lexical and semantic fluency discrepancy scores in aMCI and early alzheimer's disease. J Neuropsychol. Mar; 2009 3(Pt 1):79–92. [PubMed: 19338718]
24. Price SE, Kinsella GJ, Ong B, Storey E, Mullaly E, Phillips M, Pangnadasa-Fox L, Perre D. Semantic verbal fluency strategies in amnestic mild cognitive impairment. Neuropsychology. Jul; 2012 26(4):490–497. [PubMed: 22746308]
25. Adlam AL, Bozeat S, Arnold R, Watson P, Hodges JR. Semantic knowledge in mild cognitive impairment and mild alzheimer's disease. Cortex. Jul; 2006 42(5):675–684. [PubMed: 16909626]
26. Malek-Ahmadi M, Raj A, Small BJ. Semantic clustering as a neuropsychological predictor for amnestic-MCI. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. May; 2011 18(3):280–292. [PubMed: 21347885]
27. Cuetos F, Rodriguez-Ferreiro J, Menendez M. Semantic markers in the diagnosis of neurodegenerative dementias. Dement Geriatr Cogn Disord. 2009; 28(3):267–274. [PubMed: 19797896]
28. Baek MJ, Kim HJ, Ryu HJ, Lee SH, Han SH, Na HR, Chang Y, Chey JY, Kim S. The usefulness of the story recall test in patients with mild cognitive impairment and alzheimer's disease. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. Mar; 2011 18(2):214–229. [PubMed: 21229403]
29. Midi I, Dogan M, Pata YS, Kocak I, Mollahasanoglu A, Tuncer N. The effects of verbal reaction time in alzheimer's disease. Laryngoscope. Jul; 2011 121(7):1495–1503. [PubMed: 21647891]
30. Kawano N, Umegaki H, Suzuki Y, Yamamoto S, Mogi N, Iguchi A. Effects of educational background on verbal fluency task performance in older adults with alzheimer's disease and mild cognitive impairment. Int Psychogeriatr. Sep; 2010 22(6):995–1002. [PubMed: 20602860]
31. Hodges JR, Erzinclioglu S, Patterson K. Evolution of cognitive deficits and conversion to dementia in patients with mild cognitive impairment: A very-long-term follow-up study. Dement Geriatr Cogn Disord. 2006; 21(5–6):380–391. [PubMed: 16601329]
32. Sohlberg, M.; Mateer, C. Cognitive rehabilitation: An integrative neuropsychological approach. New York, NY: Guilford Press; 2001.
33. Ahmed S, Arnold R, Thompson SA, Graham KS, Hodges JR. Naming of objects, faces and buildings in mild cognitive impairment. Cortex. Jun; 2008 44(6):746–752. [PubMed: 18472044]
34. Duong A, Whitehead V, Hanratty K, Chertkow H. The nature of lexico-semantic processing deficits in mild cognitive impairment. Neuropsychologia. 2006; 44(10):1928–1935. [PubMed: 16616942]
35. Fleming VB, Harris JL. Test-retest discourse performance of individuals with mild cognitive impairment. Aphasiology. 2009; 23(7–8):940–950.
36. Harris JL, Kiran S, Marquardt TP, Fleming VB. Communication wellness check-up© : Age-related changes incommunicative abilities. Aphasiology. 2008; 22(7–8):813, 814–825.
37. Joubert S, Brambati SM, Ansado J, Barbeau EJ, Felician O, Didic M, Lacombe J, Goldstein R, Chayer C, Kergoat MJ. The cognitive and neural expression of semantic memory impairment in mild cognitive impairment and early alzheimer's disease. Neuropsychologia. Mar; 2010 48(4): 978–988. [PubMed: 19954747]
38. Bennett DA, Wilson RS, Schneider JA, Evans DA, Beckett LA, Aggarwal NT, Barnes LL, Fox JH, Bach J. Natural history of mild cognitive impairment in older persons. Neurology. Jul 23; 2002 59(2):198–205. [PubMed: 12136057]
39. Nordlund A, Rolstad S, Gothlin M, Edman A, Hansen S, Wallin A. Cognitive profiles of incipient dementia in the Goteborg MCI study. Dement Geriatr Cogn Disord. 2010; 30(5):403–410. [PubMed: 20975271]
40. Fleming VB, Harris JL. Complex discourse production in mild cognitive impairment: Detecting subtle changes. Aphasiology. 2008; 22(7–8):729, 730–740.
41. Price SE, Kinsella GJ, Ong B, Storey E, Mullaly E, Phillips M, Pangnadasa-Fox L, Perre D. Semantic verbal fluency strategies in amnestic mild cognitive impairment. Neuropsychology. Jul; 2012 26(4):490–497. [PubMed: 22746308]
42. Ahmed S, Arnold R, Thompson SA, Graham KS, Hodges JR. Naming of objects, faces and buildings in mild cognitive impairment. Cortex. Jun; 2008 44(6):746–752. [PubMed: 18472044]

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43. Chapman SB, Zientz J, Weiner M, Rosenberg R, Frawley W, Burns MH. Discourse changes in early Alzheimer disease, mild cognitive impairment, and normal aging. Alzheimer Dis Assoc Disord. Jul-Sep;2002 16(3):177–186. [PubMed: 12218649]
44. Schmitter-Edgecombe M, Creamer S. Assessment of strategic processing during narrative comprehension in individuals with mild cognitive impairment. J Int Neuropsychol Soc. Jul; 2010 16(4):661–671. [PubMed: 20438657]
45. Hudon C, Belleville S, Souchay C, Gely-Nargeot MC, Chertkow H, Gauthier S. Memory for gist and detail information in alzheimer's disease and mild cognitive impairment. Neuropsychology. Sep; 2006 20(5):566–577. [PubMed: 16938019]
46. Schmitter-Edgecombe M, Creamer S. Assessment of strategic processing during narrative comprehension in individuals with mild cognitive impairment. J Int Neuropsychol Soc. Jul; 2010 16(4):661–671. [PubMed: 20438657]
47. Ostberg P, Bogdanovic N, Wahlund LO. Articulatory agility in cognitive decline. Folia Phoniatr Logop. 2009; 61(5):269–274. [PubMed: 19696488]
48. Barnes DE, Yaffe K, Belfor N, Jagust WJ, DeCarli C, Reed BR, Kramer JH. Computer-based cognitive training for mild cognitive impairment: Results from a pilot randomized, controlled trial. Alzheimer Dis Assoc Disord. Jul-Sep;2009 23(3):205–210. [PubMed: 19812460]
49. Belleville S, Gilbert B, Fontaine F, Gagnon L, Menard E, Gauthier S. Improvement of episodic memory in persons with mild cognitive impairment and healthy older adults: Evidence from a cognitive intervention program. Dement Geriatr Cogn Disord. 2006; 22(5–6):486–499. [PubMed: 17050952]
50. Cipriani G, Bianchetti A, Trabucchi M. Outcomes of a computer-based cognitive rehabilitation program on alzheimer's disease patients compared with those on patients affected by mild cognitive impairment. Arch Gerontol Geriatr. Nov-Dec;2006 43(3):327–335. [PubMed: 16451811]
51. Rapp S, Brenes G, Marsh AP. Memory enhancement training for older adults with mild cognitive impairment: A preliminary study. Aging Ment Health. Feb; 2002 6(1):5–11. [PubMed: 11827617]
52. Rozzini L, Costardi D, Chilovi BV, Franzoni S, Trabucchi M, Padovani A. Efficacy of cognitive rehabilitation in patients with mild cognitive impairment treated with cholinesterase inhibitors. Int J Geriatr Psychiatry. Apr; 2007 22(4):356–360. [PubMed: 17117398]
53. Talassi E, Guerreschi M, Feriani M, Fedi V, Bianchetti A, Trabucchi M. Effectiveness of a cognitive rehabilitation program in mild dementia (MD) and mild cognitive impairment (MCI): A case control study. Arch Gerontol Geriatr. 2007; 44(Suppl 1):391–399. [PubMed: 17317481]
54. Wenisch E, Cantegreil-Kallen I, De Rotrou J, Garrigue P, Moulin F, Batouche F, Richard A, De Sant'Anna M, Rigaud AS. Cognitive stimulation intervention for elders with mild cognitive impairment compared with normal aged subjects: Preliminary results. Aging Clin Exp Res. Aug; 2007 19(4):316–322. [PubMed: 17726363]
55. Martin M, Clare L, Altgassen AM, Cameron MH, Zehnder F. Cognition-based interventions for healthy older people and people with mild cognitive impairment. Cochrane Database Syst Rev. Jan 19.2011 1:CD006220. doi(1):CD006220. [PubMed: 21249675]
56. Belleville S. Cognitive training for persons with mild cognitive impairment. Int Psychogeriatr. Feb; 2008 20(1):57–66. [PubMed: 17958927]
57. Simons-Morton, B.; McLeroy, KR.; Wendel, ML. Behavior theory in health promotion practice and research. Burlington, Massachusetts: Jones & Bartlett Learning, LLC; 2012.
58. Forbes-McKay KE, Venneri A. Detecting subtle spontaneous language decline in early alzheimer's disease with a picture description task. Neurol Sci. Oct; 2005 26(4):243–254. [PubMed: 16193251]
59. Chapman SB, Weiner MF, Rackley A, Hynan LS, Zientz J. Effects of cognitive-communication stimulation for alzheimer's disease patients treated with donepezil. J Speech Lang Hear Res. Oct; 2004 47(5):1149–1163. [PubMed: 15603468]
60. Jelcic N, Cagnin A, Meneghello F, Turolla A, Ermani M, Dam M. Effects of lexical-semantic treatment on memory in early Alzheimer disease: An observer-blinded randomized controlled trial. Neurorehabil Neural Repair. Oct; 2012 26(8):949–956. [PubMed: 22460609]

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61. Mahendra N, Arkin S. Effects of four years of exercise, language, and social interventions on Alzheimer discourse. J Commun Disord. Sep-Oct;2003 36(5):395–422. [PubMed: 12927946]
62. Ostberg P, Crinelli RM, Danielsson R, Wahlund LO, Bogdanovic N, Fernaeus SE. A temporal lobe factor in verb fluency. Cortex. Jul; 2007 43(5):607–615. [PubMed: 17715796]
63. de Zubicaray GI, Rose SE, McMahon KL. The structure and connectivity of semantic memory in the healthy older adult brain. Neuroimage. Jan 15;2011 54(2):1488–1494. [PubMed: 20807579]
64. Jack CR Jr. Alzheimer disease: New concepts on its neurobiology and the clinical role imaging will play. Radiology. May; 2012 263(2):344–361. [PubMed: 22517954]
65. Lovden M, Backman L, Lindenberger U, Schaefer S, Schmiedek F. A theoretical framework for the study of adult cognitive plasticity. Psychol Bull. Jul; 2010 136(4):659–676. [PubMed: 20565172]
66. Takeuchi H, Taki Y, Hashizume H, Sassa Y, Nagase T, Nouchi R, Kawashima R. Effects of training of processing speed on neural systems. J Neurosci. Aug 24; 2011 31(34):12139–12148. [PubMed: 21865456]
67. Mozolic JL, Hayasaka S, Laurienti PJ. A cognitive training intervention increases resting cerebral blood flow in healthy older adults. Front Hum Neurosci. Mar 12.2010 4:16. [PubMed: 20300200]
68. Park DC, Reuter-Lorenz P. The adaptive brain: Aging and neurocognitive scaffolding. Annu Rev Psychol. 2009; 60:173–196. [PubMed: 19035823]
69. Geva S, Jones PS, Crinion JT, Price CJ, Baron J, Warburton EA. The effect of aging on the neural correlates of phonological word retrieval. J Cogn Neurosci. Nov.2012 24(11):2135. 2146 ER. [PubMed: 22849403]
70. Meinzer M, Flaisch T, Seeds L, Harnish S, Antonenko D, Witte V, Lindenberg R, Crosson B. Same modulation but different starting points: Performance modulates age differences in inferior frontal cortex activity during word-retrieval. Plos One. Mar 15.2012 7(3):e33631. [PubMed: 22438970]
71. Carretti B, Borella E, Zavagnin M, de Beni R. Gains in language comprehension relating to working memory training in healthy older adults. Int J Geriatr Psychiatry. May; 2013 28(5):539–546. [PubMed: 22821686]
72. Belleville S, Gilbert B, Fontaine F, Gagnon L, Menard E, Gauthier S. Improvement of episodic memory in persons with mild cognitive impairment and healthy older adults: Evidence from a cognitive intervention program. Dement Geriatr Cogn Disord. 2006; 22(5–6):486–499. [PubMed: 17050952]

Table 1

Observational studies with communication variables

Reference	Subjects	Communication Domain(s)	Communication Measurement(s)	Principal Findings
		Cross-Sectional Studies: Expressive Language Domains		
Adlam et al., 2006 [25]	MCI=10 AD=11 NCI=30	Semantic memory, verbal fluency	Portions of the Cambridge Semantic Battery (3 semantic fluency tasks, picture naming, word to picture matching), concrete and abstract synonym test, Pyramid and Palm Trees test of associative semantic knowledge, phonemic fluency task, and a multi- component battery of semantic knowledge constructed by the authors	Phonemic fluency: MCI=NCI>AD; semantic fluency: AD<MCI<NCI. MCI not statistically different from NCI on any other measures of semantic memory, better than AD on picture naming, word-picture matching, word synonyms, Pyramids and Palm Trees test.
Ahmed et al., 2008[42]	MCI=32 NCI=37	Semantic memory	Graded naming test (GNT), Graded Faces Test (GFT), Graded Buildings Test (GBT)	MCI<NCI on all tasks. In both groups, scores on GNT>GBT>GNT. 31% of MCI participants impaired on 1 test, 28% impaired on 2, 28% impaired on all 3, 13% impaired on none; 13% of controls impaired on 1 test, 87% impaired on none. Combination of all 3 tasks correctly predicted 78.1% of MCI participants, 100% of controls.
Baek et al., 2011 [28]	Korean subjects: MCI=112 AD=97 NCI=53	Semantic memory, verbal fluency, expressive and receptive discourse	BNT, Controlled Oral Word Association Test (COWAT; semantic and phonemic fluency), immediate and delayed story recall and story recognition test	Semantic memory, verbal fluency, immediate and delayed story recall tests: AD<MCI<NCI. Story recognition task: AD<MCI=NCI. Sensitivity and specificity of story recall for identifying MCI and AD was low in participants with ≤6 years of education, but acceptable in those with ≥7 years.
Balthazar et al., 2008 [16]	aMCI=16 mild AD=16 NCI=16	Semantic memory, verbal fluency	BNT, semantic fluency (animal naming) task	BNT total score (with cues): AD<aMCI=controls. BNT spontaneous naming (without cues): AD<aMCI<controls. Verbal fluency scores: AD<aMCI<controls.
Brandt & Manning, 2009[17]	MCI=74 aMCI-sd=25 aMCI-md=27 naMCI=22 AD=29 NCI=40	Verbal fluency	Multiple semantic and phonemic fluency tasks	aMCI-sd showed no difference between semantic and phonemic fluency, similar to NCI. aMCI-md had poorer semantic than phonemic fluency, similar to AD.
Bschor et al., 2001[18]	MCI=34 Mild AD=21 Mod-severe AD=20 NCI=40	Expressive discourse, semantic memory, verbal fluency	Boston Diagnostic Aphasia Examination-3 (BDAE-3) Cookie Theft Picture, BNT, semantic and phonemic fluency tasks	All groups produced similar numbers of words on picture description (expressive discourse); task did not differentiate between MCI and mild AD or MCI and NCI. Semantic memory and verbal fluency: AD<MCI<NCI.
Carter et al., 2012[19]	MCI=17 Probable mild AD=15 NCI=13	Verbal fluency, semantic memory	Phonemic and semantic fluency tasks, GNT, language portions of Addenbrooke's Cognitive Examination-Revised (ACE-R) and Face Place Test (FPT)	Phonemic and semantic fluency: AD<MCI<NCI. Semantic memory: AD=MCI<NCI. Less challenging language section of ACE-R showed AD<NCI; did not discriminate MCI.
Chapman et al., 2002 [43]	MCI=20 Mild AD=24 NCI=25	Expressive and receptive discourse, reading comprehension	578-word narrative with gist- and detail-level probes, read aloud by examiner with participant following along	Production of accurate inferences from the story: AD=MCI<NCI. Main idea and lesson from the story, and statement of important information: AD<MCI<NCI.
Cuetos et al., 2009[27]	MCI=40 Probable AD=40 SCI=20 NCI=40	Semantic memory, verbal fluency	Naming famous faces and objects, semantic and phonemic fluency tasks, definition-word matching, synonym matching	Naming faces, definition-word matching, semantic fluency: MCI<NCI. Naming faces and objects, semantic fluency and definition-word matching: AD<MCI. Naming faces, definition-word matching and semantic fluency were good predictors of SCI vs. MCI vs. AD.

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Reference	Subjects	Communication Domain(s)	Communication Measurement(s)	Principal Findings
Duong et al., 2006 [34]	MCI=61 Probable AD=39 NCI= 60	Semantic memory	Psycholinguistic Assessment of Language picture naming task, semantic probes (answering questions about pictures), 2 lexical decision tasks (word vs. non-word), Stroop, and Stroop-Picture naming task	MCI group impaired relative to NCI on picture naming and semantic probes, but not lexical decision; AD group impaired on all relative to MCI. MCI group impaired on Stroop picture naming but not Stroop.
Economou A et al., 2007[20]	aMCI=37 mild AD=15 NCI=27	Verbal fluency	Semantic fluency task	AD<a-MCI<NCI.
Fernaeus et al., 2008[21]	MCI=82 AD=58 NCI=45	Verbal fluency	3 tests each of phonemic and semantic fluency	AD<MCI<NCI. MCI and NCI performed better on semantic fluency than phonemic.
Fleming & Harris, 2008[40]	MCI=8 NCI=8	Semantic memory, expressive discourse	BNT, and complex, elicited discourse sample ("Trip to New York"), analyzed for 13 thematic core concepts	MCI performed similarly to NCI on BNT. MCI scored poorer, compared to NCI, on discourse length and quality, but not syntactic complexity.
Hall et al., 2011 [22]	MCI=97 VD=97 AD=249 NCI=45	Verbal fluency	Semantic fluency task, scored over 4 15-second blocks	After 15 seconds, MCI performed significantly better than AD or VD; After 30 seconds, MCI performed significantly poorer than NCI.
Harris et al., 2008 [36]	MCI=10 Persons with neurological damage (PWND)=10 NCI (younger)=30 NCI (older)=22	Expressive discourse, semantic memory	"Trip to New York" discourse task analyzed for 13 thematic core concepts, and BNT	MCI provided less thematic information than all other groups. MCI and PWND provided more irrelevant comments and were more verbose than NCI groups. Semantic memory: MCI=PWND<NCI.
Hudon et al., 2006 [45]	MCI=20 AD=14 NCI=26	Expressive discourse, reading comprehension	Recall of detail and gist information from narrative text	Detail and gist measures: AD<MCI<NCI.
Joubert et al., 2010[37]	aMCI=15 early AD=16 NCI=16	Semantic memory	Naming 20 objects, 20 animals and 30 faces, and answering questions about them	Naming objects and faces, and on semantic knowledge (answering questions about named objects and faces): AD=MCI<NCI..
Kawano et al., 2010 [30]	Japanese subjects: MCI=123 AD=345 AD	Verbal fluency	1 semantic fluency and 1 phonemic fluency task	MCI produced more words than AD. Level of education influenced performance on semantic fluency, but not phonemic fluency in MCI and AD participants
Lonie et al., 2009 [23]	aMCI=47 early AD=35 NCI=24 Depression=18	Verbal fluency	1 semantic fluency and 1 phonemic fluency task	AD<a-MCI<NCI. aMCI and early AD patients show a greater discrepancy between semantic and phonemic fluency than controls (semantic scores<phonemic scores).
Midi et al., 2011[29]	MCI=15 early AD=15 moderate AD=8 NCI=15	Verbal fluency, verbal reaction time and motor speech	Phonemic fluency, semantic fluency, multidimensional voice parameters, maximum phonation time, DDK rate, spectrogram	MCI produced more words with faster reaction times than AD on verbal fluency tasks; not significantly different from NCI. No statistically significant difference on DDK rate in MCI as compared to early AD (mod-severe AD were slower). MCI had faster sentence repetition than those with mod AD; not statistically different from NCI. MCI produced more intense (louder) speech than AD; not statistically different from NCI.
Ostberg et al., 2005	MCI=60 AD=57 Subjective cognitive impairment (SCI)=40	Verbal fluency	Phonemic, semantic and verb fluency tasks	Verb fluency scores: AD<MCI<SCI. MCI subjects performed poorer on verb fluency than other verbal fluency tasks
Ostberg et al., 2009[47]	chart reviews of: MCI=89 AD=58 SCI=60 Fronto-temporal dementia (FTD)=13 Progressive nonfluent aphasia	Motor speech	DDK rate	Only 10% of MCI participants showed impaired motor speech performance. DDK rates for MCI were not significantly different from any group, except were significantly faster than PNFA.

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Reference	Subjects	Communication Domain(s)	Communication Measurement(s)	Principal Findings
	(PNFA)=7 Semantic dementia (SD)=9			
Price, et al., 2012 [24]	aMCI=33 NCI=33	Verbal fluency, semantic memory	2 semantic fluency tasks, BNT-2 (15 item form)	aMCI produced smaller clusters, fewer subcategories and a non-significantly fewer number of switches than NCI. Semantic memory: MCI=NCI.
Schmitter-Edgecombe & Creamer, 2010 [44]	aMCI=23 NCI=23	Expressive and receptive discourse, reading comprehension	Two 20-line stories read by participants one line at a time, giving them a chance to “think aloud” to help them remember. Then asked 5 factual and 5 inferential questions	MCI participants were more impaired than controls on production of inferences and story retelling.
Zamarian et al., 2010 [11]	MCI=18 Mild AD=18 NCI=18	Verbal fluency, semantic memory, reading comprehension	Semantic fluency task, BNT (short form), Aachner Aphasie Test	MCI scored poorer than NCI on verbal fluency and semantic memory tasks and better than AD on semantic memory. No difference between groups on reading comprehension task.
Cross-Sectional Studies: Receptive Language Domains				
Baek et al., 2011 [28]	Korean subjects: MCI=112 AD=97 NCI=53	Semantic memory, verbal fluency, expressive and receptive discourse	BNT, Controlled Oral Word Association Test (COWAT; semantic and phonemic fluency), immediate and delayed story recall and story recognition test	Semantic memory, verbal fluency, immediate and delayed story recall tests: AD<MCI<NCI. Story recognition task: AD<MCI=NCI. Sensitivity and specificity of story recall for identifying MCI and AD was low in participants with ≤6 years of education, but acceptable in those with ≥7 years.
Chapman et al., 2002 [43]	MCI=20 Mild AD=24 NCI=25	Expressive and receptive discourse, reading comprehension	578-word narrative with gist- and detail-level probes, read aloud by examiner with participant following along	Recognition and remembering of story details: AD<MCI<NCI
Schmitter-Edgecombe & Creamer, 2010 [44]	aMCI=23 NCI=23	Expressive discourse, reading comprehension	Two 20-line stories read by participants one line at a time, giving them a chance to “think aloud” to elicit inferences and aid memory. Then asked 5 factual and 5 inferential questions	Story comprehension: MCI<NCI.
Hudon et al., 2006 [45]	MCI=20 AD=14 NCI=26	Expressive discourse, reading comprehension	Recall of detail and gist information from narrative text	Detail and gist measures: AD<MCI<NCI.
Zamarian et al., 2010 [11]	MCI=18 Mild AD=18 NCI=18	Verbal fluency, semantic memory, reading comprehension	Semantic fluency task, BNT (short form), Aachner Aphasie Test	MCI scored poorer than NCI on verbal fluency and semantic memory tasks and better than AD on semantic memory. No difference between groups on reading comprehension task.
Longitudinal Studies: Expressive Language Domains				
Bennett et al., 2002 [38]	Catholic clergy: MCI=211 NCI=587 Assessed 1 time per year for an average of 4.5 (range1–7) years	Semantic memory (conceptualized as a composite of semantic memory, verbal fluency, comprehension of sentences and paragraphs, and reading comprehension)	Composite z-score of: BNT, verbal fluency task, “Complex Ideational Material” subtest of BDAE, Extended Range Vocabulary Test, National Adult Reading Test	MCI persons scored poorer at baseline and declined faster than controls in semantic memory.

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Reference	Subjects	Communication Domain(s)	Communication Measurement(s)	Principal Findings
Fleming & Harris, 2009 [35]	MCI=8 Assessed at baseline and 6- months	Expressive discourse	BNT and complex, elicited discourse sample (“Trip to New York”), analyzed for 13 thematic core concepts	No significant decline in expressive discourse after 6 months
Hodges et al., 2006 [31]	MCI=10 NCI=24 Assessed 1 time/year for 6–10 years	Verbal fluency, semantic memory, semantic knowledge, syntactic knowledge	8 semantic fluency tasks, 3 phonemic fluency tasks, picture naming, Pyramids and Palm Trees (PPT) test of associative semantic knowledge, Test for the Reception of Grammar	Compared to NCI, MCI showed impairments only in semantic fluency throughout the study period, and for phonemic fluency at year 6. All other tests showed no significant differences between groups, after statistical adjustment for multiple comparisons
Nordlund et al., 2010 [39]	MCI=260 N=205 assessed at both baseline and 2 year time points	Sentence comprehension. semantic memory, abstraction (similarities)	Token test (subtest V), Assessment of Subtle Language Deficits repetition, BNT, Similarities subtest of Weschler’s Adult Intelligence Scale-Revised	After 2 years, 47 (23%) of MCI group had dementia and 9 (5%) demonstrated normal cognitive function. 62% of MCI participants who progressed to dementia were initially impaired on semantic memory, and 40% on auditory comprehension.
Longitudinal Studies: Receptive Language Domains				
Nordlund et al., 2010 [39]	MCI=260 N=205 Assessed at baseline and 2 years	Sentence comprehension. semantic memory, abstraction (similarities)	Token test (subtest V), Assessment of Subtle Language Deficits repetition, BNT, Similarities subtest of Weschler’s Adult Intelligence Scale-Revised	After 2 years, 47 (23%) of MCI group had dementia and 9 (5%) demonstrated normal cognitive function. 62% of MCI participants who progressed to dementia were initially impaired on semantic memory, and 40% on auditory comprehension.

Note. MCI=mild cognitive impairment; NCI=no cognitive impairment; AD=Alzheimer’s disease; aMCI=amnestic MCI; naMCI=nonamnestic MCI; sd=single domain; md=multiple domain; VD=vascular dementia; DDK rate=diadochokinetic rate (a measure of articulatory agility measured by repetitions of the syllables “pa-ta-ka”).

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Table 2

Cognitive Intervention studies with communication outcomes

Reference	Sample	Communication Domain(s)	Measure(s)	Design	Intervention	Communication Results
Barnes et al., 2009 [48]	MCI=47 I=22 C=25	Verbal fluency, semantic memory	Repeatable Battery for Assessment of Cognitive Status language domain score, Controlled Oral Word Association Test, Boston Naming Test (BNT)	RCT; baseline and post-intervention assessments	Home-based computerized training exercises to improve auditory processing speed and accuracy 100 min. per day, 5 days/week, for 6 weeks	No statistically significant difference between intervention and control on communication measures
Belleville et al., 2006 [72]	MCI=25 I=17 C=8 NCI=17 I=9 C=8	Receptive and expressive discourse (episodic memory)	Immediate and delayed story recall	Quasi-experimental; baseline and post-intervention assessments	Memory strategy training. 8 weekly sessions of 120 min. in small groups of 4–5 participants	Story recall did not significantly improve in either MCI or NI participants
Cipriani et al., 2006 [50]	MCI=10 AD=10 MSA=3	Verbal fluency (phonemic and semantic)	Phonemic and semantic fluency tasks	Quasi-experimental; baseline and 3-month follow-up assessments	Multi-modal computerized cognitive training of attention, memory, perception, visuospatial cognition, language. 2 4-week periods of training separated by ~6 week break. Subjects trained 4 days/week for 13–45 min.	MCI group did not improve on language measures from baseline to follow-up; AD group improved on phonemic fluency; MSA group showed no change
Rapp et al, 2002 [51]	MCI=19 I=9 C=10	Receptive and expressive discourse (episodic memory)	Immediate and delayed story recall	RCT; Baseline, post-intervention and 6-month follow-up assessments	Memory intervention including education regarding memory impairment, relaxation training, memory skills training, "cognitive structuring of memory-related beliefs" (p. 5). Six weekly 120-minute group sessions.	No statistically significant change in communication measure in I or C group
Rozzini et al. , 2007[52]	MCI=59 Cog I=22 Pharm+ Cog I=15 C=22	Verbal fluency (semantic and phonemic), receptive and expressive discourse (episodic memory)	Phonemic and semantic fluency tasks, story recall	RCT; Baseline and 1-year follow-up assessments	Multi-modal computerized cognitive training of attention, memory, abstract reasoning, visuospatial skills, language. 3 blocks of training (with 2 month breaks between blocks) of 1 hour/day, 5 days/week for 4 weeks.	Pharm+cog training group improved on discourse (story recall) following intervention; no change in other groups or on verbal fluency measures
Talassi et al., 2007[53]	MCI=37 I=30 C=7 Mild dementia=29 I=24 C=5	Verbal fluency (semantic and phonemic), receptive and expressive discourse (episodic memory)	Phonemic and semantic fluency tasks, Rivermead Behavioural Memory Test (RBMT) story recall	Quasi-experimental; baseline and post-intervention assessments	Multi-modal intervention including computerized cognitive training (CCT), occupational therapy (OT) and behavioral training (BT). 30–45 min. sessions for each activity, 4 days/week for 3 weeks.	No statistically significant changes in communication measures in either MCI or AD I groups. AD C group improved on semantic verbal fluency task

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Reference	Sample	Communication Domain(s)	Measure(s)	Design	Intervention	Communication Results
Wenisch, 2007 [54]	MCI=12 NCI=12	Verbal fluency (semantic and phonemic)	Semantic and phonemic fluency tasks	Quasi-experimental; baseline and post-intervention assessments	Multi-modal intervention for memory, executive function and visuo-spatial skills utilizing cognitive strategy training delivered over 10 weekly 90-minute small group sessions.	No statistically significant change in verbal fluency

Note. MCI=mild cognitive impairment; NCI=no cognitive impairment; I=Intervention; C=control; Cog=cognitive; Pharm=pharmacological; MSA=multi-system atrophy