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Cognitive Prescriptions: A Nursing Approach to Increasing Cognitive Reserve

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Abstract

Non-pathological cognitive declines occur with aging, which negatively affects everyday functioning and reduces quality of life. Many elders, aware of such cognitive changes, seek ways to bolster their cognitive functioning. Evidence based on the cognitive aging literature supports a number of factors associated with cognitive functioning. These factors include physical exercise, intellectual exercise, nutrition, sleep hygiene, social interaction, and mood and emotional state. These factors can be manipulated and woven together by nurses and other medical professionals to develop an easy to use, non-invasive cognitive prescription for improving the cognitive health of their patients. An example and directions for developing and implementing cognitive prescriptions are described.

Rowe and Kahn (1997) defined successful aging as the possession of three essential components: (1) low probability of disease and disability, (2) active engagement in life, and (3) optimal cognitive and physical functioning. Cognitive functioning may be the most important component of successful aging, as it directly underlies everyday functioning.

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Optimal cognition is required to regulate active engagement in life and to maintain health promoting behaviors such as remembering to take one's medications in an effort to avoid disease and disability.

Cognitive functioning becomes especially germane given that 21% of community-dwelling older adults (mean age = 66.2 years) experience memory complaints (Minett, Silva, Ortiz, & Bertolucci, 2008). Such complaints frequently correspond to measures of cognitive functioning. In a sample of community-dwelling older adults without dementia in their 70's, one third was identified with observable cognitive deficits (Low et al., 2004). Though one third may be small in number, moderate cognitive deficits without dementia interfere with everyday tasks (e.g., grocery shopping, taking medication, housework, driving), and represents a significant and growing problem for formal and informal caregivers (McGuire, Ford, & Ajani, 2005).

The purpose of this article is to provide gerontological nurses with evidence, based in the cognitive literature, to protect and augment cognitive functioning in their aging patients through the introduction of cognitive prescriptions. Cognitive prescriptions are individualized, behavioral instructions designed to support existing cognitive functioning through principles of neuroplasticity, cognitive reserve, and healthy lifestyle. This article will address four major concepts: (1) the foundation of neuroplasticity and cognitive reserve, (2) a brief review of the major factors known to affect cognitive reserve, and thus cognitive functioning (Figure 1), (3) instructions for taking this information and combining it with the patient's history in order to demonstrate the development of an individualized cognitive prescription (Figure 2), and (4) implications for nursing practice.

Cognitive Reserve and Neuroplasticity

Cognitive reserve refers to the number, strength, and sophistication of connects between the neurons from which cognitive functioning emerges. The greater this cognitive reserve, the more resistant one is to age and disease-related insults to the brain and thus better one's cognitive ability. Cognitive reserve increases by a mechanism referred to as positive neuroplasticity and decreases through negative neuroplasticity. Positive neuroplasticity refers to environmental stimuli or other novel stimuli, as well as physiological mechanisms, that result in building cognitive reserve resulting in sustained or improved cognitive functioning; likewise, negative neuroplasticity refers to the lack of environmental and novel stimuli and physiological problems that result in depleting cognitive reserve which jeopardize cognitive functioning (Vance & Crowe, 2006). Such mechanisms have been observed in animals, taxi drivers, older adults, and adults with dementia.

Animal studies using the enriched environmental paradigm have shown that one's surrounding stimuli can increase cognitive reserve and change the morphology of the brain. In the classic experiments using this paradigm, Diamond (1993) randomly placed genetically similar rats into one of three environments: enriched, standard, and impoverished. In the enriched environment, 12 rats were placed in a large cage with toys to explore. These toys were replaced regularly with new toys to explore. In the standard environment, three rats were placed together. In this condition, the rats had fewer rats with

which to interact and had no toys to explore. In the impoverished condition, rats were placed in isolation in a cage with no toys to explore.

Diamond (1993) discovered that rats living in the more enriching conditions had a corresponding increase in the size of their cerebral cortex and increase in neuronal density and complexity. Subsequent studies found that this increase in cognitive reserve corresponded to better performance on maze tasks, a proxy measure of cognitive functioning (Paban, Jaffard, Chambon, Malafosse, & Alescio-Lautier, 2005). From such studies, the principles of neuroplasticity are clearly demonstrated.

In London taxi drivers, the effect of positive neuroplasticity increasing cognitive reserve is observed in several studies (e.g., Maguire et al., 2000). London taxi drivers receive extensive training over a 2-4 year period in order to earn their license; during this time, they learn the layout of 25,000 streets and thousands of points of interest. Using magnetic resonance imaging (MRI), Maguire, Woollett, and Spiers (2006) compared London bus drivers, who drive on a set route, to these London taxi drivers who explore the entire city. The bus and taxi drivers were matched on stress level and years of driving experience. These researchers found that compared to the bus drivers, the taxi drivers exhibited larger gray matter volume in the mid-posterior hippocampi. Furthermore, years of driving experience correlated with such gray matter volume in the hippocampus, but only in the taxi drivers; no such correlation existed for the bus drivers who were driving on set routes. Such clear morphological changes show the impact that environment and novel stimuli (i.e., learning London streets) can have on cognitive reserve.

Principles of neuroplasticity are observed in older adults as well. Noice, Noice, and Staines (2004) assigned 124 community-dwelling older adults (60 – 86 years) to one of three conditions: A theatre training condition, a visual art appreciation condition, or a no-contact control condition. The researchers posited that theatrical acting is a highly developed skill requiring a range of affective, physical, and cognitive resources that must be integrated. Theatre training represents the active treatment condition whereby participants received nine 90-minute acting lessons. Using a pre-post experimental design, those assigned to the theatre training condition experienced improvements in memory and reasoning; such improved cognitive functioning is indicative of increased cognitive reserve. Another similar study by Mahncke, Bronstone, and Merzenich (2006), further demonstrates that exposure to novel and challenging stimuli, in this case computer gaming software designed with interesting mental exercises, can facilitate positive neuroplasticity which can increase cognitive reserve and thus ameliorate cognitive functioning.

The principles of neuroplasticity highlight ways in which cognitive reserve may delay the on-set of cognitive symptoms associated with Alzheimer's disease. Roe et al. (2008) examined whether older adults with higher levels of education possessed better cognitive functioning than older adults with lower levels of education while examining various levels of fibrillar brain amyloid associated with Alzheimer's disease. Education is considered novel environmental stimuli that encourages neuroplasticity and promotes cognitive reserve, and thus improves cognitive functioning. Radiotracers were used to detect the level of fibrillar beta-amyloid pathology during a positron emission tomography of the prefrontal cortex,

lateral temporal cortex, gyrus recturs, and precuneus regions-of-interest. The presence of beta-amyloid pathology statistically interacted with the years of education in predicting cognitive scores. The results demonstrated that the higher the level of education, used as a proxy of cognitive reserve, the better one's cognitive functioning, even in the presence of beta-amyloid pathology. These results suggest that promoting cognitive reserve, whether through positive neuroplastic effects of education or other means, may delay the symptoms of Alzheimer's disease; however, such an approach is not expected to stop the progression of Alzheimer's disease or other such dementias.

Although beyond the scope of this article, the biochemistry behind neuroplasticity and cognitive reserve is quite complex. Studies show that in some brain regions, there are progenitor cells in the adult brain with the capacity to replace existing neurons that are damaged. Likewise, existing neurons also show the ability to change connections and density of dendritic connections. Such compensatory neurogenesis and alterations of neurons occur in response to novel stimuli. The attention devoted to novel, and often challenging, stimuli in the environment can produce an amount of stress that activates hormonal and neural regulators which produce changes in the morphology of neurons, increasing cognitive reserve. Such cognitive reserve is manifested in improved cognitive functioning (Kozorovitskiy, & Gould, 2003). For more empirical support and explanation of biological mechanisms involved with neuroplasticity and cognitive reserve, readers are encouraged to view two special issues -- *Journal of Clinical and Experimental Neuropsychology* (Vol. 25, No. 5) and *The Gerontologist* (Vol. 49, No. S1).

Contributing Factors to Positive and Negative Neuroplasticity

Vance, Roberson, McGuinness, and Fazeli (2010) proposed a model whereby several factors can influence neuroplasticity, cognitive reserve, and cognitive functioning either positively or negatively. Although by no means exhaustive, the more germane factors that promote such cognitive health include physical exercise, intellectual exercise, nutrition, sleep hygiene, social interaction, and mood and emotional state (Figure 1). These factors can be manipulated individually or collectively to improve cognitive functioning as directed in a cognitive prescription. In other words, there are protective factors that can delay the loss of cognitive reserve and improve cognitive reserve. In contrast, there are risk factors that facilitate decreasing cognitive reserve capacity.

Physical Exercise

Physical exercise improves cardiovascular and physiological functioning which exerts a positive effect on neurological health; neurological health facilitates positive neuroplasticity. For example, Colcombe et al. (2006) randomized 59 sedentary, community-dwelling older adults (60 – 79 years) to a 6-month clinical trial whereby half were assigned to an aerobic training condition and the other half were assigned to a toning and stretching condition; this last condition served as the non-aerobic control group. Analysis of MRI scans administered before and after training revealed that compared to the control group, the adults in the aerobic training condition experienced significant increases in the volume of gray and white matter regions of the brain. These results support the importance that physical activity has in promoting positive neuroplasticity and increasing cognitive reserve over the lifespan.

Intellectual Exercise

Intellectual pursuits, such as educational attainment, have been shown to promote positive neuroplasticity thus facilitating cognitive reserve (Vance & Crowe, 2006). In a national birth cohort, Richards, Hardy, and Wadsworth (2003) examined the relationship between intellectual pursuits, as measured by leisure activities (e.g., church and volunteer activities, playing games), and their relationship to cognitive functioning. Controlling for gender, educational level, occupational social class, intellectual quotient at adolescence, mental distress, and health status, the amount of engagement in leisure activities from 36 years of age was significantly associated with performance on a memory test at 43 years of age.

Boyke, Driemeyer, Gaser, Büchel, and May (2008) studied the physiological changes in the brain of 25 older adults (mean age = 60 years) who were taught to juggle. The researchers gathered MRI scans on these older adults at baseline, three months later when they learned to juggle, and then three months later when the older adults did not practice juggling and lost this ability. Compared to baseline measures, immediately after learning to juggle, MRI scans revealed increased gray matter volume in the hippocampus and the nucleus accumbens, brain structures necessary for memory consolidation. Similarly, when older adults stopped juggling, MRI scans three months later revealed a loss of volume in these same brain structures. This study exemplifies the process of positive and negative neuroplasticity in humans.

Other intellectual pursuits have been developed to improve cognitive functioning through a series of specifically designed exercises referred to as cognitive remediation therapy. For example, Vance et al. (2007) administered a speed of processing training, a type of cognitive remediation therapy, to community-dwelling older adults (mean age = 75 years). Speed of processing training consisted of ten 1-hour sessions whereby older adults were presented computer tasks that required them to identify central and peripheral targets on a screen. In this adaptive training, the rate of these presentations gradually increased or decreased based on their responses. If the older adults responded correctly, the next presentation would become slightly faster; if incorrectly, the next presentation would become slightly slower. By doing this, the threshold of one's visual speed of processing would be reached and then expanded through this training. Nearly one half of the older adults received this speed of processing training (n = 82), and the other half (n = 77) received internet training to counterbalance the confounding variables of social and computer contact. Researchers found that those in the active treatment experienced cognitive gains on neuropsychological measures of visual speed of processing immediately after training; such gains were robust over a two-year period. Other computerized, cognitive remediation training programs have been shown to improve other cognitive skills (e.g., memory, reasoning) as well (Mahncke et al., 2006).

Nutrition

One reason poor nutrition is a factor of negative neuroplasticity is because some foods such as sugars and foods poor in antioxidants, create inflammatory responses in the brain or are not protective against normal everyday inflammatory effects created by stress. These effects are cumulative over time and can gradually impede positive neuroplasticity. Requejo et al.

(2003) examined the nutritional intake of 168 community-dwelling older adults (65 – 90 years) and found that lower consumption of sweets, greater consumption of fish, the amount of food in general, and moderate alcohol use was associated with better cognitive functioning. Wärnberg, Gomez-Martinex, Romeo, Días, and Marcos (2009) posited that even modest changes in diet may have significant public health implications on cognitive functioning.

Sleep Hygiene

Many sleep hygiene problems occur more frequently with age (Redline et al., 2004). Compounding this problem, many adults may use over-the-counter medications, alcohol, or prescription medications to assist with sleep problems. Unfortunately, such techniques disrupt the sleep architecture which negatively impacts cognitive functioning (Roehrs, Hollebeek, Drake, & Roth, 2002). In fact, the type of sleep one receives is extremely important for cognitive functioning. Stickgold (2005) described several studies whereby participants were asked to perform three different cognitive tests – a motor sequence test, a motor adaptation test, and a visual texture discrimination test. In these studies, Stickgold found that participants improved on these tests after one night of sleep; such findings were not observed for participants after being awake for an equivalent amount of time. Furthermore, the results demonstrated that improvements in these cognitive tests correlated with the amount of specific types of sleep. Improvements found in the motor sequence test were correlated with non-rapid eye movement (non-REM) sleep. Improvements found in the motor adaptation test were correlated with slow-wave sleep (SWS). Improvements found in the visual texture discrimination test were correlated with REM and SWS. These studies show that sleep-dependent consolidation of memory depended on not one, but several stages of sleep. How different stages of sleep contribute to specific types of memory consolidation is not well understood; however, this lack of knowledge does not preclude that good sleep hygiene has a positive impact on cognitive functioning.

Social Interaction

Similar to the enriched environmental paradigm discussed earlier, Lu et al. (2003) housed rats with either other rats or in isolation during 4 to 8 weeks. When researchers examined the rats' brains, they discovered that rats in the social condition experienced more neurogenesis in the hippocampus, the brain region needed for memory. This finding supports the positive role that social interaction plays on neuroplasiticty. Studies suggest that older adults who are integrated socially have less risk for developing dementia, or at least have later on-set dementia (Fratiglioni, Paillard-Borg, & Winblad, 2004). In fact, given the complex nature of human social interaction, neuroscientists posit its importance in promoting positive neuroplasticity and cognitive reserve (Gheusi, Ortega-Perez, Murray, & Lledo, 2009). Furthermore, social interaction is related to mood and depression, which can independently affect cognition.

Mood and Emotional State

Fuchs, Czéh, Kole, Michaelis, and (2004) reported that exposing male tree shrews to a chronic psychosocial stress paradigm, a model that reflects the pathophysiology of depression, was associated with reduced concentration of brain metabolites (e.g., choline-

containing compounds, N-acetyl-aspartate) and hippocampal changes associated with apoptosis. These researchers asserted that the negative effects of stress on the brain and hippocampus may be counteracted by antidepressants to mitigate the loss of structural plasticity.

In humans, the effects of depression on cognitive functioning are well documented (Comjis, Jonker, Beekman, & Deeg, 2001). In a structural equation modeling study of 158 community-dwelling older adults (mean age = 75 years), Vance, Wadley, Ball, Roenker, and Rizzo (2005) found that increasing levels of depressive symptomatology had a direct path (i.e., relationship) to cognitive functioning. Neuroscientists proposed that reducing depression through antidepressants and therapy will promote positive neuroplasticity and improve cognitive reserve and thus facilitate cognitive functioning (Fuchs et al., 2004; Reid & Stewart, 2001).

Implications for Practice

Contributing factors to positive and negative neuroplasticity can be theoretically be manipulated alone or together to improve cognitive functioning. For example, in a current study being conducted, Ball et al. (NIH/NIA Grant No. 5 R37 AG05739-16) are examining whether combining speed of processing training with physical exercise will result in improved cognitive functioning in community-dwelling older adults versus physical activity or speed of processing training alone. This approach of combining such factors embodies the principle of creating a cognitive prescription for patients.

By combining these factors, nurses can generate an individualized cognitive prescription for their patients. To create such a cognitive prescription, three essential components are required. First, the nurse must have a working knowledge of what factors contribute and detract from good cognitive health. The basics for that information are presented here in this article and further in other articles (e.g., Mahncke et al., 2006; Vance & Wright, 2009). In general, those things which are good for the body are also good for the brain. For example, substance abuse (i.e., alcohol, smoking) places demands on the liver, kidneys, lungs, and heart. In so doing, this also means that the brain may have poor oxygenated blood, fewer nutrients, and more teratogens that interfere with neural functioning. Second, the nurse must assess the patient's personal, social, and medical status to determine areas where cognitive functioning may be compromised or augmented due to health or lifestyle. Motivational interviewing may also prove to be an effective strategy for assessing the patient in order to facilitate compliance to the goals that are developed. Thus, this process entails asking patients detailed questions about physical exercise, intellectual exercise, nutrition, sleep hygiene, social interactions, and mood and emotional state. It also entails gathering medical information such as medical condition (e.g., hypertension, heart disease, diabetes) or medications (e.g., benzodiazapines) which can also either help or hinder cognitive functioning. This is especially relevant if there are concerns about polypharmacy which is common in older adults and is well known to negatively impact cognitive functioning (Vance, Larsen, Eagerton, & Wright, in press). Finally, the nurse must integrate her or his knowledge of cognitive health with the patient's history to create a behavioral program that suggests activities in which the patient can engage to protect or improve cognitive

functioning (See Figure 2). It is important to make the behavioral program as specific as possible; making the instructions concrete serves to help with adherence and monitoring of the cognitive prescription (LaVigna & Donnellan, 2007).

Figure 2 demonstrates a cognitive prescription for an elderly lady who reports cognitive complaints. During the assessment of the patient, the nurse inquires about each of the factors that can impact cognitive function and establishes goals in each area based on the patient's ability to comply. For example, recognizing that the patient suffers from depression, and understanding that depression contributes to poorer cognitive functioning, an obvious action would be to assess medication compliance with the antidepressant. The nurse, as a health educator, must explain to the patient the importance of the antidepressant and ensure that the patient understands how the medications are to be taken. The nurse must comprehend how the various factors are integrated and be capable of explaining this interdependence to the patient. For example, in Figure 2 the relationship between physical exercise and sleep hygiene is closely aligned and both are important factors to enhance cognitive functioning.

Obviously, the cognitive prescription provided in Figure 2 serves only as a rubric. Other factors may be considered given their negative impact on cognitive functioning such as substance use, diabetes, or heart disease (Beeri Goldbourt, Silverman, Noy, Schmeidler, Ravona-Springer et al., 2004). Thus, treatment for such comorbidities can be incorporated with the cognitive prescription. Cognitive prescriptions may also be useful in cognitively vulnerable populations with such comorbidities such as those with multiple sclerosis and those aging with HIV (Vance & Burrage, 2006). Such an approach may be more useful for nurses, such as psychiatric nurses, who have more one-on-one time with patients over extended periods of time.

Conclusion

Nurses are in a key position to listen to their older patients' concerns and complaints about their cognitive functioning, to assess their patient's cognitive function, and to provide interventions to improve their quality of life. Cognitive prescriptions provide a practical, non-invasive approach for augmenting cognitive functioning while also providing suggestions for improving health and vitality. However, this approach has not been used on adults with cognitive impairment and data must continue to be generated to evaluate this approach. In fact, no study has examined the use of the proposed cognitive prescription for improving cognitive health in normal community-dwelling older adults. It is unclear at this point how compliant and receptive older adults may be to such cognitive prescriptions. Likewise, it also uncertain whether certain cognitive abilities, such as memory, would improve more or less compared to other cognitive abilities, such as reasoning, as a result of using a cognitive prescription, or whether there would simply be an overall gain in cognition. Fortunately, we do know that the individual components of the cognitive prescription have been shown to independently improve cognitive reserve as exhibited by improved cognitive functioning in older adults. Thus, it is hoped that by combining such individual components together in a comprehensive prescription, cognitive improvements may be even more robust when used with older adults. Given the growing number of older adults with cognitive deficits, cognitive prescriptions represent a way of improving,

maintaining, or mitigating cognitive decline, thus facilitating optimal everyday functioning and performance. As with any intervention study among older adults, the ultimate goal is to increase independence and quality of life. Such a formalized strategy may become more popular as the number of older adults with subjective concerns about their cognitive functioning increases and nurses are better educated about assessing, planning, and interviewing through the utilization of cognitive prescriptions.

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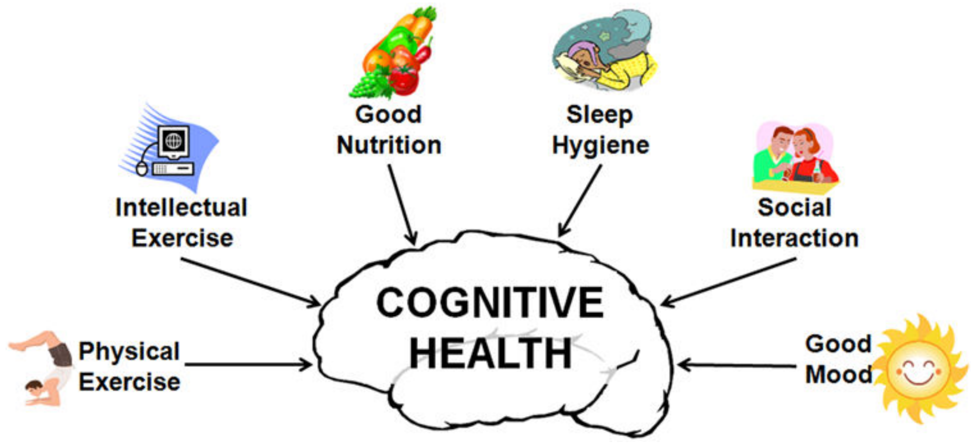
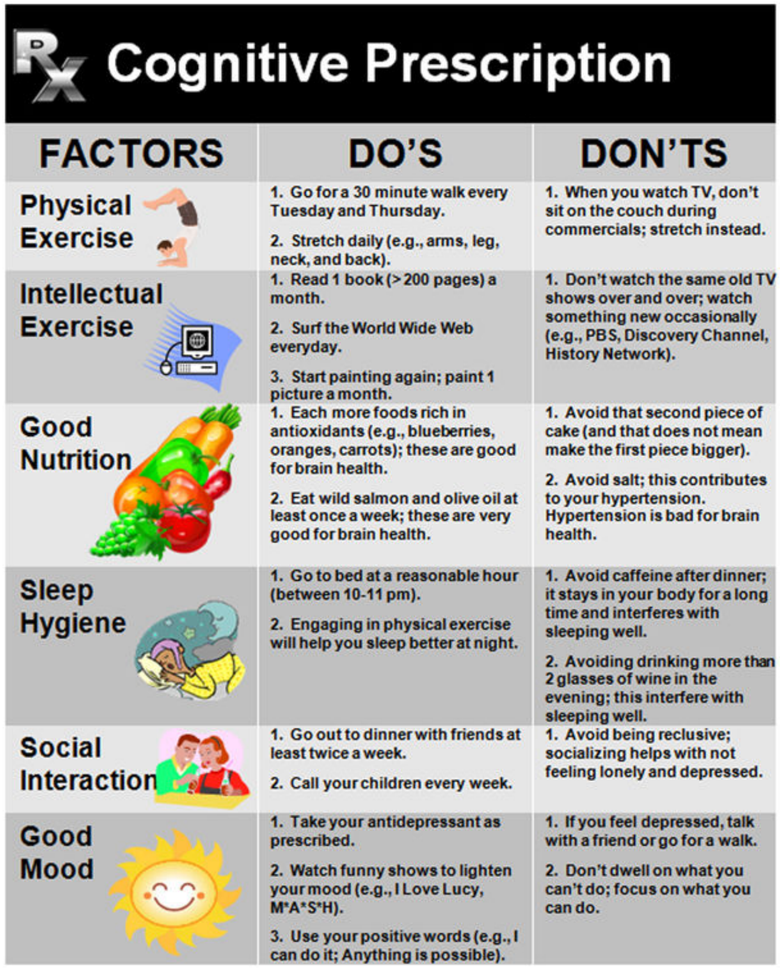


Figure 1.
Factors That Promote Cognitive Health.



Cognitive Prescription

FACTORS	DO'S	DON'TS
Physical Exercise	1. Go for a 30 minute walk every Tuesday and Thursday. 2. Stretch daily (e.g., arms, leg, neck, and back).	1. When you watch TV, don't sit on the couch during commercials; stretch instead.
Intellectual Exercise	1. Read 1 book (> 200 pages) a month. 2. Surf the World Wide Web everyday. 3. Start painting again; paint 1 picture a month.	1. Don't watch the same old TV shows over and over; watch something new occasionally (e.g., PBS, Discovery Channel, History Network).
Good Nutrition	1. Each more foods rich in antioxidants (e.g., blueberries, oranges, carrots); these are good for brain health. 2. Eat wild salmon and olive oil at least once a week; these are very good for brain health.	1. Avoid that second piece of cake (and that does not mean make the first piece bigger). 2. Avoid salt; this contributes to your hypertension. Hypertension is bad for brain health.
Sleep Hygiene	1. Go to bed at a reasonable hour (between 10-11 pm). 2. Engaging in physical exercise will help you sleep better at night.	1. Avoid caffeine after dinner; it stays in your body for a long time and interferes with sleeping well. 2. Avoiding drinking more than 2 glasses of wine in the evening; this interfere with sleeping well.
Social Interaction	1. Go out to dinner with friends at least twice a week. 2. Call your children every week.	1. Avoid being reclusive; socializing helps with not feeling lonely and depressed.
Good Mood	1. Take your antidepressant as prescribed. 2. Watch funny shows to lighten your mood (e.g., I Love Lucy, M*A*S*H). 3. Use your positive words (e.g., I can do it; Anything is possible).	1. If you feel depressed, talk with a friend or go for a walk. 2. Don't dwell on what you can't do; focus on what you can do.

Figure 2.

Example of a Cognitive Prescription.