

Preliminary Support of a Behavioral Intervention for Trait Conscientiousness in Multiple Sclerosis

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Background: Conscientiousness, or the proclivity for deliberation, achievement, and order, declines in many individuals with multiple sclerosis (MS). Decreased conscientiousness predicts future cognitive deterioration, brain atrophy, and employment loss in individuals with MS. As a psychological trait, it may be an actionable antecedent to these important outcomes. We pilot tested an application (app)-facilitated behavioral intervention to help adaptation to low conscientiousness and, in turn, improve employment.

Methods: Eleven individuals with MS (5 treatment, 6 control) with low conscientiousness were recruited for a 12-week randomized controlled trial. The treatment group received a newly developed behavioral treatment and smartphone app designed to help people behave more conscientiously, 2 teleconference booster sessions, and weekly telephone calls to monitor progress. Employment changes were recorded at baseline and follow-up. Patients provided detailed posttreatment interviews.

Results: Participant groups were matched on baseline age, sex, education, disease duration, hours worked, and conscientiousness. All participants in the treatment arm reported benefits, found the app easy to use, and would recommend it to others. The treatment group reported significantly more positive work outcomes relative to controls at follow-up ($P = .028$). Other positive life changes were described by treatment participants during post-treatment interviews.

Conclusions: These results support the hypothesis that behaviors typically associated with low conscientiousness may be addressed by behavioral therapy in the MS population. In addition to the positive employment changes in the treatment group, several other quality of life changes were described by study participants. Additional research is needed. *Int J MS Care*. 2022;24(2):45-53. doi:10.7224/1537-2073.2021-005

Approximately 50% of persons with multiple sclerosis (MS) lose their jobs within 5 years of diagnosis, with an eventual unemployment rate of up to 80%.¹ Because of the impact and the rapidity with which job loss occurs, it is important to identify and test potentially actionable antecedents. One particularly strong predictor of employment loss in individuals with MS is low trait

conscientiousness.^{2,3} This key component of the Big Five or Five-Factor Model of personality refers to one's proclivity for deliberation, achievement, and order.⁴ Low conscientiousness predicts employment loss in individuals with MS even after accounting for education, race, fatigue, cognition, and physical disability.³ Conscientiousness declines longitudinally in individuals with MS,⁵ and in addition to predicting employment loss, low conscientiousness also predicts faster rates of cognitive decline and brain atrophy^{6,7} and increased susceptibility to mood or anxiety disorders.⁸

If these predictions are the result of differences in behavior, then treatments aimed at altering conscientiousness-associated behaviors ought to benefit maintenance of employment. Research is needed to determine: (1) whether conscientiousness can be accommodated to alter behavior and (2) whether

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such accommodations improve functional outcomes. Preliminary work shows that high-conscientiousness individuals with MS have greater improvement with cognitive rehabilitation,⁹ are more likely to disclose their MS status at work, and are more likely to have received work accommodations, such as flexible work hours.³ Behaviors such as these may moderate the protective relationship between higher baseline trait conscientiousness and future employment outcomes.

Several theoretical approaches have been described for potentially increasing conscientiousness, or at least for helping people behave more conscientiously.¹⁰⁻¹³ Interventions are currently only conceptual and have yet to be performed in individuals with MS. One proposal is to help patients compensate for lowered conscientiousness using external tools, as there is still debate about whether conscientiousness, as a fixed personality trait, can be changed.¹⁰

In this randomized controlled pilot study, we evaluated a technology-assisted intervention, using in-person psychotherapy, telehealth psychotherapy, and a smartphone application (app) designed as an external aid to enhance value-oriented thinking and behavior, improve self-discipline, hone achievement of goals, and prevent negative employment outcomes. For this intervention, we applied principles from within the motivational framework of expectancy value theory (EVT), which “integrates personal motives and personality to demonstrate how identity shapes values, goals, and subsequent behaviors.”¹² The primary outcome for this value-oriented intervention was improved work status. Because conscientiousness is expected to affect a range of life outcomes, we also explored the impact of treatment on other functional activities, such as family relationships and physical well-being. Unfortunately, this study was closed prematurely owing to the global COVID-19 pandemic, limiting the sample size.

Methods

This study was approved by the University at Buffalo institutional review board. Written informed consent was obtained from all the study participants.

Participants

All the study participants were aged 18 years or older and had a diagnosis of MS. Additional inclusion criteria were a NEO Five-Factor Inventory (NEO-FFI)⁴ conscientiousness age- and sex-corrected *T* score of 1 SD or more below the healthy adult mean (*T* = 40), employed and working more than 10 hours per week, and no history of substance

dependence/abuse, psychiatric disorders, or neurologic disease other than MS. Participants were also required to own an iPhone or Android smartphone.

Eleven participants were recruited and randomized to either the intervention (*n* = 5) or control (*n* = 6) group. For randomization, study participants were assigned to one of the 2 groups at the time of recruitment by a trained research assistant (M.G.J., and O.A.-K.) using a random number generator. Treatment group participants underwent the intervention as described later herein. Both groups were assessed using the same assessment batteries and were compensated for their participation (\$50 per assessment). Of the 5 treatment group participants, 4 gave additional written consent to have anonymized case study-style vignettes published about their participation.

Intervention Timeline

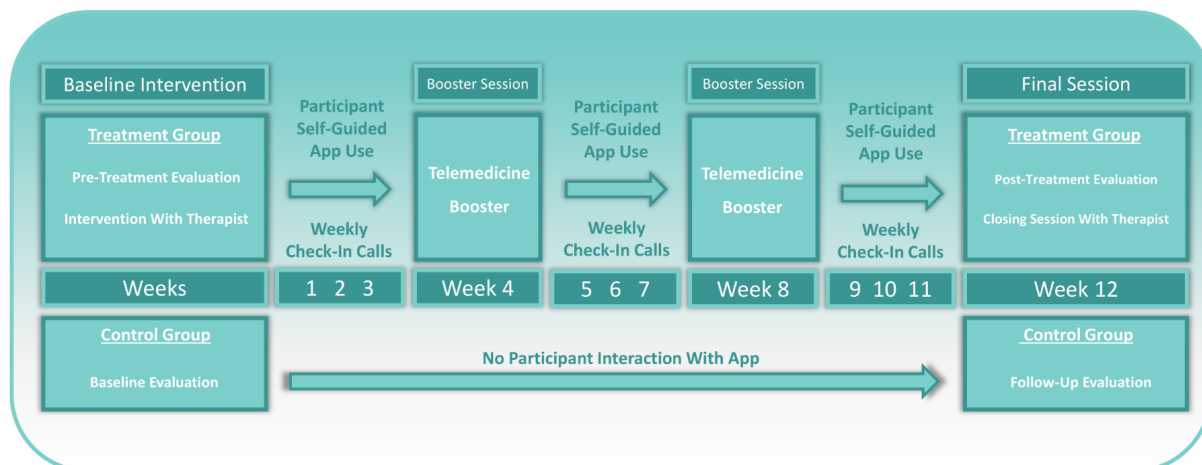
The timeline of the study is described in **Figure 1**. At baseline, the treatment group met with a trained provider (T.A.E.), hereafter referred to as coach/therapist, under the supervision of a board-certified neuropsychologist (R.H.B.B.) for the initial treatment session (~60 minutes). The treatment group then met with the coach/therapist for treatment booster sessions (~45 minutes) at weeks 4 and 8 and a post-treatment interview at week 12. Treatment booster sessions scheduled before March 2020 were completed in person, and those scheduled after were conducted remotely via telehealth because of the COVID-19 pandemic. The treatment group also received weekly telephone calls (~5 minutes) for technical support and brief progress updates with trained research assistants. Baseline and follow-up assessments were conducted by independent evaluators (M.G.J., M.Y., O.A.-K.), separate from the coach/therapist, to prevent bias from confounding results. Control participants underwent the same baseline and follow-up assessments but did not receive treatment or a placebo (ie, treatment as usual).

Intervention

According to EVT, “individuals with high valuing of and expectations for success at a task would show ambitious goal-setting, persistence, effort, and subsequent achievement.”¹² Thus, EVT provides a useful framework for understanding how to select behaviors that the individual may be more likely to practice and persist in over time. The conscientiousness intervention was designed with EVT in mind, expecting that by directing patients to make behavioral changes according to their own values, that the changes would be more meaningful and more likely to persist over time. This can be thought of as a “bottom-up” approach, where behavioral change is motivated by deeply held beliefs and values, rather than by external motivations.

For all psychotherapy encounters, humanistic therapy techniques were applied, such that the coach/therapist engaged the patient on the assumption that they are

Figure 1. Study Timeline



Treatment group participants underwent 12-week intervention starting with baseline (week 0) neuropsychological evaluation (~1 hour) and intervention (~1 hour). Intervention included education regarding conscientiousness, evaluation of each patient's values, and development of SMART (Specific, Measurable, Achievable, Realistic, and Time-bound) goals contributing toward these values. Participants were shown how to use conscientiousness-coach application (app) and were contacted weekly to review technical issues and goal progress. Teleconferenced booster treatment (~45 minutes) was performed during weeks 4 and 8 at which conscientiousness concepts were reaffirmed and coach/therapist helped patient evaluate and adapt goals, discuss obstacles, and acknowledge achievements. Follow-up neuropsychological evaluation and closing session were completed during week 12 at which patients were encouraged to continue using app. Waitlist controls were given same neuropsychological evaluations at both time points but did not receive treatment.

inherently driven to actualize their values—and want to grow towards what they deem to be most important to them. Accordingly, the coach/therapist provided the patient unconditional positive regard in their intent to turn their values into actionable goals. To help the patients set and achieve goals that contribute towards the fulfillment of their values, cognitive behavioral therapy techniques were also used. These techniques were applied to assist the patient in transitioning from their understanding of what is most important to them (their values) and focusing on contributing towards these values with actionable behaviors (goals).

During the baseline treatment session (~60 minutes), participants were provided information about conscientiousness, its components, its relationship with health and employment outcomes, and how it can decline in some individuals with MS. From this, participants were then directed to reflect on their values and goals. These discussions were based on theoretical assumptions from EVT.¹² Based on their values, participants were then asked to reflect on what they would like to change or improve in their lives. Commonly listed values revolved around the importance of family, employment, spirituality, and health. Participants then set goals or actionable plans working toward tangible objectives that are consonant with their values (Figure S1, which is published in the online version of this article at IJMSc.org). Because low conscientiousness is associated with reduced orderliness, goal

orientation, and dependability, the coach/therapist gave participants a framework for setting goals in order of priority (eg, planning a shopping list and purchasing fruits and vegetables may precede the goal of eating 3 to 4 servings of fruits and vegetables each day). As well, participants were asked to set goals that were specific, measurable, achievable, realistic, and time-bound (SMART)¹⁴ so that they could hold themselves accountable for the goals they set. For example, rather than set a goal such as “spend more time with family,” participants were instead directed to set goals such as “have 4 ‘sit-down’ dinners with family each week.” When setting goals, patients were asked “On a scale from 1 to 10, how confident are you that the goal you set is realistic and achievable, given the other pressures in your life?” Patients were encouraged to alter their goals if confidence was below 7. After this initial conversation about conscientiousness, values, and value-oriented goals, participants were provided with the conscientiousness-coach app (CCA) for the smartphone (Figure S2) and instructed in its use. They input values and value-oriented goals into the app with the coach/therapist and were instructed on how the app would help them follow their own progress, provide them with helpful notifications, and keep track of scheduled/completed activities.

At weeks 4 and 8, participants teleconferenced with a coach/therapist for the booster treatment session (~45 minutes). During this session participants were directed to discuss their accomplishments and achievements related

to the goals and tasks they set on the app and reflected on how their lives have changed as a result. Participants also discussed any issues or obstacles they might have faced, how they overcame them, and how they may keep doing so for future challenges while trying to make headway on their CCA goals. They worked with the coach/therapist to reevaluate and modify existing goals on the CCA and set new goals if appropriate; using the CCA they were directed to continue to build/alter values and value-associated goals. The coach/therapist closed each session by appraising the participants' successes and reaffirming descriptions of conscientiousness and how the app and treatment are designed to relate to trait conscientious and associated behaviors.

In addition to these booster sessions, treatment participants were contacted weekly by telephone (1-2 minutes) to ensure that questions or CCA-based issues were addressed quickly. During these weekly calls participants were also asked to report goal progress and CCA use.

Conscientiousness-Coach App

We designed the CCA with the aim of helping individuals compensate for lower conscientiousness (Figure S2, developed with the help of Foxspin, LLC). The app does this by helping people consider what is most important to them, their values, and helping them organize their behaviors into goals that contribute toward these values. As such, the app is designed to benefit value-orientation, goal-achievement, and orderliness components of conscientiousness. Features such as push notifications and daily reminders are also intended to affect key components of conscientiousness, such as dependability and self-accountability.

Through the CCA, values are represented with a unique icon on the app home page, and each has its own page for tracking goals contributing to that value. The CCA encourages users to input SMART goals, and the goals input to each value page can also be added to a to-do list and/or calendar, with options for repeated events and event push notifications. Users can rearrange and label goals according to priority and track their level of success for each goal. Ultimately, users can mark goals as nonstarted, started, or complete, and the proportion of completed goals for each value page are reported to the user. Users also receive daily notifications, reminding them to reflect on their values and goals. Clicking on these reminders brings them to the CCA home screen, where all the icons for their values are shown. This is intended to help individuals develop a habit of reflecting on what is most important to them and how well their behaviors are contributing to these core values.

Pretreatment and Posttreatment Evaluation

At baseline, all the participants were assessed by a trained research assistant, independent of the coach/therapist, using the following measures: California Verbal Learning Test, Second Edition,¹⁵ a 16-item word list

learning test with 5 learning trials; Brief Visuospatial Memory Test-Revised,¹⁶ a test of visual/spatial learning and memory presenting a matrix of 6 figures over 3 learning trials; Symbol Digit Modalities Test,¹⁷ a test emphasizing visual processing and cognitive processing speed; Nine-Hole Peg Test,¹⁸ a form board peg placement task emphasizing fine motor dexterity and coordination; Timed 25-Foot Walk test,¹⁹ a measure of timed ambulation; Fatigue Severity Scale (FSS),²⁰ a 9-question self-report scale measuring subjective ratings of fatigue; Beck Depression Inventory Fast Screen,²¹ a 7-question self-report measure of depressive symptoms; NEO-FFI participant- and informant-report (age- and sex-corrected *T* scores used for final evaluation),²² a 60-item self- and informant-report questionnaire measuring 5 personality domains (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism); Multiple Sclerosis Work Difficulties Questionnaire (MSWDQ-23),²³ a 23-item self-report measure examining the subjective rating of difficulty when performing work tasks across 3 broad domains (psychological/cognitive barriers, physical barriers and, external barriers); and the Quality of Life in Neurological Disorders (Neuro-QOL) subscales Communication, Ability to Participate in Social Roles and Activities, Satisfaction with Social Roles and Activities, and Positive Affect.²⁴ The Buffalo Vocational Monitoring Survey (BVMS)²⁵ was administered online, without supervision, before and after treatment. The BVMS was used to gather work-related information such as work hours, employment status, work-related problems, accommodations, and negative work events. Examples of negative work events captured by the BVMS include verbal criticism for errors, decrease in work hours, removal of responsibilities, formal discipline, mandated additional support or training, and asked to work additional hours to complete duties.

Posttreatment assessment was more limited and conducted via telemedicine owing to concerns regarding the spread of COVID-19 infection. The assessment included the NEO-FFI, Beck Depression Inventory, FSS, MSWDQ-23, Neuro-QOL, and BVMS.

Statistical Analyses

To confirm that the app treatment and control groups were matched on baseline demographics and characteristics (age, sex, education, disease duration, disease course, hours worked, and trait conscientiousness), we applied *t* test and χ^2 analyses where appropriate. We compared the treatment group with the control group on the primary outcome, positive changes in work outcomes, according to changes on the online-administered BVMS. Positive change in work outcomes was defined as diminution in negative work events, increase in income, increase in work accommodations, or increase in self-maintenance techniques used at work between the pretreatment and posttreatment evaluations. In addition, we applied a 2-way analysis of variance

Table 1. Participant Demographic Characteristics

Characteristic	Treatment group (n = 5)	Control group (n = 6)	P value
Age, y	47.0 ± 9.0	43.3 ± 8.1	.495
Female sex	80.0	83.3	.887
Education, y	15.6 ± 2.3	14.5 ± 2.2	.436
RRMS disease course	100.0	83.3	.338
Disease duration, y	11.0 ± 5.8	16.7 ± 3.4	.073
Time working for pay, h/wk	34.6 ± 10.9	29.3 ± 11.0	.449
Trait conscientiousness (T score)	32.4 ± 10.3	33.0 ± 13.8	.938

RRMS, relapsing-remitting multiple sclerosis.

Note: Data are given as mean ± SD or percentage. Independent-samples t tests and χ^2 tests were used to measure differences in numerical and categorical variables at baseline.

test to assess effects of group, time, and group × time on self-report trait conscientiousness.

Results

Group Analysis

There were no statistically significant differences found between the treatment and control groups regarding baseline age, sex, education, disease duration, disease course, hours worked, or trait conscientiousness (Table 1). The treatment group reported significantly more positive work outcomes relative to controls at follow-up ($P = .028$). Improved work outcomes for the treatment participants included increased work accommodations, such as flexible work hours, and promotions to positions of increased salary/responsibility. No significant effect of group or time was observed for trait conscientiousness, Beck Depression Inventory Fast Screen, FSS, MSWDQ-23, and Neuro-QOL. When using the CCA, all the treatment participants found it easy to use, and all reported that they benefited from the app and the intervention. Four of 5 patients in the treatment group indicated that they would continue to use the app after closure of the study, and all said that they would recommend the app to friends.

Vignettes

As stated previously herein, written informed consent was provided by all the study participants described in the vignettes. Identifiable personal and employment information described were altered to protect anonymity. One treatment group participant requested that their case study remain unpublished.

Case 1

The patient is a 47-year-old woman with an 8-year history of relapsing-remitting MS (RRMS). She works as a health aid for approximately 37 hours per week,

and her Conscientiousness score was $T = 27$ ($z = -2.33$). During the baseline intervention the patient identified several principal values, such as the importance of living a healthy lifestyle, career fulfillment, the importance of intimacy with her extended family, and development of mindfulness.

To start living a healthier lifestyle, her first goal included adding more fruits and vegetables to her diet (3-4 servings per day). She was previously eating less than 1 to 2 servings of fruits/vegetables per day because of her busy work schedule. She also set a goal to walk approximately 10,000 steps each day. Relating to her relationships with her extended family, the patient decided to contact her aunts and brothers to arrange lunches and other social events once each week. Regarding career fulfillment, she decided to set aside time to research educational requirements needed to receive baccalaureate training for a professional health care position, researching over the course of 1 month. Regarding the development of mindfulness, she decided to shut her phone off before bed 2 to 3 times each week.

The patient reported using the CCA approximately 4 to 5 times a week. At follow-up she was maintaining a more balanced diet by adding fruits and vegetables to each of her meals during the day. She attributed this success to the CCA notification and reminder features. She also was spending more time with her extended family by having lunches with her aunts approximately 2 times a month and texting her brothers a few times each week. The patient acknowledged that advancing her career through baccalaureate training was presently unrealistic due to the extensive time required. This ultimately led her to alter her career advancement goal by instead focusing on her current position and exploring possible promotions via development of a leadership presence at work. She stated that she would continue working on this goal even after completion

of the study. By the end of the study, she felt more mindful because she turned her phone off 2 to 3 nights each week. Overall, because she was following her set tasks she felt that she was procrastinating less. The patient reported that she enjoyed using the app and rated its ease of use as 7 of 10. She would highly recommend use of the CCA to others, and at study completion she indicated that she planned to continue using it.

Case 2

The patient is a 50-year-old woman with a 21-year history of RRMS. She works approximately 32 hours per week as a personal shopper. During the baseline intervention she indicated that she valued physical health, her relationship with God, positive employment conditions, and her spousal relationship.

The patient committed to improving her physical health during the study by eating fruits and vegetables 3 times a week. She also planned on allocating more time away from the television once each week to instead do something more health-positive, such as physical therapy exercises. To improve her relationship with God, she planned to set aside time to read the bible twice each week and pray for 5 minutes 4 times each week. Due to her physically demanding job and MS-related fatigue, she wanted to improve her working conditions. To do so, she planned to acknowledge her physical limitations and improve her work conditions by talking to upper management about receiving accommodations. She planned to approach and discuss her options with management before the end of the study. To improve her spousal relationship, she hoped to spend 2 days a week cleaning the house one room at a time, cooking dinner twice a week, and improving communication.

At the follow-up visit the patient reported using the CCA approximately 3 to 4 times each week. She was able to complete almost all the goals she set for herself and felt that she was fulfilling her values. She reported using the CCA each Sunday to organize herself before each week. On study completion, she reported living a healthier lifestyle by eating fruits and vegetables 5 days of the week. She also spent much more time thinking about her relationship with God. In addition, she communicated with her employer about her needs. As a result, she was provided work accommodations with more flexible work hours, more breaks, and shorter units of labor. The patient had a frank conversation with her spouse about being more open and honest with each other, and afterward communication

improved. In addition, she cleans part of a room each day and as a result has had a tidier house. The patient reported that she enjoys using the CCA, rated ease of use as 8 of 10, and would recommend it to others. At study completion, she indicated that she intended to continue using the app.

Case 3

The patient is a 42-year-old woman with a 10-year history of RRMS. She works approximately 15 hours per week as a retail merchandiser. At the baseline intervention she indicated that she valued good health, civic engagement, and her relationship with her family, specifically her children's happiness.

Regarding her health, the patient planned to lose 10% of her body weight. To do so, she set out to exercise 4 times each week in the afternoon. In relation to civic engagement, her goal was to research possible volunteer options and offer her time to an organization within 2 weeks of the initial intervention. In addition, in relation to her relationship with her family, she planned to have sit-down dinners with them once each week. As well, she planned to set aside one-on-one time with a different child each week, such as recreational walking or playing at the park.

At follow-up the patient reported using the CCA at least once each day and that she had achieved most of her goals. She was having healthy sit-down meals with her family 4 times a week while trying out new recipes. Her children provided a helping hand with food preparation, which she says benefits everyone involved. She reported that her children were learning useful cooking skills. She was not as fatigued when cooking because of the help, and she was able to spend more time with her children. She also reported that she had been avoiding desserts and maintaining a healthier diet in general.

The patient had been experiencing distractions when exercising and decided to alter her goal by working out in the mornings instead of afternoons, while most of her family is still asleep. She also asked her children not to interrupt while she is exercising. She had been exercising 2 to 3 times a week with ambitions of eventually exercising 5 to 6 times each week. Her goal of losing 10% of her body weight is still in progress. She had also been going on 25-minute walks 1 to 2 times each week with a different child each time. She had opened up communication with her daughters and has had sincere conversations with them about the importance of exercising for long-term health, especially alongside chronic illness. She hoped

that this set an example for her children, so they may view exercising more so for long-term health than for improving physical attractiveness. After researching available options, she decided to volunteer at a local animal shelter but was unable due to COVID-19–related state restrictions. Instead she reached out to Meals on Wheels via her daughters' school and plans to deliver food to those in need alongside her daughter, allowing them to spend more quality time together.

The patient reported that the CCA and related intervention had helped keep her values and goals salient among daily distractions. She was proud of what she had achieved and says that she had proved to herself that her life goals can be planned, progressed, and accomplished. She mentioned that having a CCA to-do list of tasks to complete every day has kept her focused, reminded her of important daily tasks, and overall put her at ease by helping her be more organized. At the conclusion of the study, she said she would continue using the app and would suggest it to others, rating its ease of use as 7 of 10.

Case 4

The patient is a 36-year-old woman with a 9-year history of RRMS who works approximately 40 hours per week as a financial investigator. During the baseline intervention she emphasized that she values physical health, family togetherness, organization in home life, and career fulfillment.

In relation to good health, the patient planned to begin regularly taking her MS medication, something she previously struggled with. She decided she would use the CCA to be reminded of this task each morning. Regarding family togetherness, she planned to set aside time once each week for her family to sit down for dinner without electronics. Regarding organization in the home, she planned on cleaning 1 room per day, 3 days each week. Last, regarding career fulfillment, she planned to pursue a promotion at work. To accomplish this, she set up several tasks, such as maintaining good performance overall. In addition, she planned to exceed the minimum “case completion” requirement each week by 2 to 3 cases and taking on additional responsibilities when offered.

The patient attended all required sessions and reported using the CCA at least once each day. At study completion she was taking her MS medication daily, which she reports was thanks to the CCA notifications. Her family had been eating dinner together once each week without electronics. Her home was

also more organized because she had been cleaning a room each day, 3 days a week. Last, she received her desired promotion at work and believes that the CCA helped her achieve this. She rated the app as 7 of 10 for ease of use and would recommend it to others.

Discussion

This small randomized controlled trial of a newly developed cognitive behavioral, app-facilitated, intervention for low conscientiousness resulted in improved work outcomes over 3 months ($P = .028$) relative to the no-treatment control group. In the small sample, this effect was significant because of a work promotion reported by one participant in the treatment group and the receipt of new work accommodations for another. No such positive work outcomes were reported by the control group. Low conscientiousness in individuals with MS is associated with higher risk of employment loss.³ The conscientiousness-focused treatment and CCA mitigated that risk over 3 months.

This study was terminated prematurely due to the global COVID-19 pandemic. Consequent to these circumstances, the study sample was small and follow-up data collection was limited. As a result, only one major outcome was investigated statistically. However, we qualitatively explored other changes in the lives of treatment group participants and uncovered a range of other potential benefits of treatment. During post-treatment assessment, treatment group participants reported changes in work and home life, enhanced work accommodations, and improved spiritual life. One of the treated participants received a promotion at work. The CCA was rated as easy to use, and 4 out of 5 participants said that they would continue to use the CCA after closure of the study. We are encouraged by these findings, which suggest that a more definitive study could be worthwhile.

In addition to demonstrating the efficacy of the newly developed CCA, this study also provides preliminary validation of previously described theoretical frameworks for improving or accommodating low conscientiousness. In the development of the intervention, we used principles in the motivational framework of EVT, which considers the manner in which personality, identity, and personal values contribute to the development of goals and subsequent behaviors.¹⁰⁻¹³ We also applied psychotherapy techniques derived from cognitive behavioral and humanistic psychotherapy. Patients were provided education about conscientiousness and were asked to organize their values

in order of importance. They then set value-oriented goals that were measurable and realistic.

These results beg the question of whether personality traits can actually be modified. Based on the pretreatment and posttreatment NEO-FFI *T* scores, there was no significant shift in conscientiousness. We do not believe that this study has resulted in any significant change in personality, although the study was brief and longer application of the CCA could perhaps enhance conscientiousness as measured by the NEO-FFI. Another way to conceptualize this intervention is that of compensation. We provided coaching and an external aid that enabled patients to overcome the limitations of low conscientiousness and in doing so adopt healthier and adaptive behaviors. In other words, we taught the participants how to behave more conscientiously within the confines of this app-assisted intervention. It remains to be seen whether the behavioral gains are replicated, and importantly how long they are maintained without further coaching. Long-term follow-up is planned and will be included in future clinical trials.

Previous work shows that low conscientiousness is associated with higher levels of unemployment in individuals with MS and occupational stress.²⁶⁻²⁸ More recently, we also showed that low conscientiousness at baseline predicts employment loss over 3 years, even after controlling for neurologic disability and cognitive dysfunction.³ We posited that this employment loss is likely mediated through conscientiousness-associated behaviors. People maintaining employment were more

likely to have disclosed their MS status at work and to have received work accommodations, such as flexible work hours. The present work provides evidence that negative work outcomes in individuals with MS with low conscientiousness can be addressed through compensatory behavioral methods. Treatment group participants exhibited improved work outcomes after changing their behaviors in a conscientiousness-focused manner, but without changing underlying trait conscientiousness.

In addition to the impact of the present intervention and conscientiousness-focused smartphone app in individuals with MS, addressing low conscientiousness may have benefits in other disease groups. For example, lower conscientiousness is associated with lower quality of life in patients with Parkinson disease,²⁹ increased incidence of Alzheimer disease in individuals with mild cognitive impairment,^{30,31} higher triglyceride and low-density cholesterol levels,³² higher risk of becoming diabetic,³³ higher average blood glucose levels in individuals with diabetes,³⁴ greater risk of stroke and coronary heart disease,³⁵ and higher rates of all-cause mortality in normal aging.³⁶ For all these groups, this conscientiousness-based intervention may also help mitigate negative clinical outcomes associated with lower conscientiousness.

This is only a pilot study, with many research design limitations. Study enrollment and follow-up were ended prematurely owing to the COVID-19 pandemic. Consequently, the sample size was small. Although these findings provide support of concept, future work should include a larger sample size with more statistical power to validate the findings, explore other outcomes, and include a more diverse patient sample to enhance the generalizability of the results and examine characteristics or types of employment underscoring patient likelihood of responding to treatment. In addition, this study lasted only 3 months. With a longer intervention and observation period, it is possible that other measurable changes could be observed. A longer duration, and perhaps software modifications to the CCA, would also allow us to monitor user engagement during the intervention as well as later, when there is likely less novelty promoting CCA use. Although the CCA can be used at home independently, it currently requires that patients initially meet with a trained clinical provider to begin using the app. The CCA could be improved in future iterations by including features that guide users as the clinician might and, therefore, allow them to interact with the app more independently. Future work is

PRACTICE POINTS

- Trait conscientiousness, or the proclivity for deliberation, achievement, and order, predicts cognitive decline, brain atrophy, and negative employment outcomes in individuals with MS. Frequently diminished in this population, as a psychological trait it may be amenable to behavioral intervention.
- A newly developed application-facilitated intervention for low conscientiousness improved work outcomes over 3 months in at-risk individuals with MS relative to controls. This value-based tool is flexible and may have use in other clinical populations for a wide range of functional outcomes.
- This pilot intervention was conducted on a small sample, and follow-up was interrupted by circumstances relating to the COVID-19 pandemic. Additional work is needed to validate the present findings.

needed to ensure that these results persist with more stable research conditions.

In conclusion, conscientiousness-focused therapy and an accompanying phone app were designed to accommodate low conscientiousness and its associated risks (eg, employment loss) and behaviors. We applied these tools in a randomized controlled trial and observed improved work outcomes over 3 months in high-risk, low-conscientiousness individuals with MS relative to controls ($P = .028$). These results and the qualitative study findings provide preliminary evidence supporting the feasibility and use of these tools for improving work outcomes in individuals with MS who are at high risk for employment loss due to low conscientiousness. Further study is indicated to validate these findings, to explore other important functional outcomes, and to determine the usefulness of these tools in other clinical populations. □

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