Trends
in Psychiatry and Psychotherapy

Original Article

Effects of a single-session facial emotion recognition training using the MTS paradigm in cognitively unimpaired older adults

Marcos Hortes N. Chagas, Bianca Leticia C. Ferreira, Laura Lobrigatti Pelaes, Ana Julia L. Bomfim

http://doi.org/10.47626/2237-6089-2025-1082

Original submitted Date: 02-Apr-2025

Accepted Date: 19-Dec-2025

Effects of a single-session facial emotion recognition training using the MTS paradigm in cognitively unimpaired older adults

Running title: MTS-based FER training in older adults

Marcos Hortes N. Chagas[1*], Bianca Leticia C. Ferreira[1], Laura Lobrigatti Pelaes[2], Ana Julia L. Bomfim[1,2]

[1]Departamento de Neurociências e Ciências do Comportamento, Universidade de São Paulo, São Paulo, SP, Brazil.

[2]Departamento de Gerontologia, Centro de Ciências Biológicas e da Saúde, Universidade Federal de São Carlos, São Carlos, SP, Brazil.

[*]Corresponding author: Marcos Hortes N. Chagas; Departamento de Neurociências e Ciências do Comportamento da Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo. Av. Bandeirantes, 3900; CEP: 14048-900 - Ribeirão Preto - SP – Brasil
E-mail: mchagas@fmrp.usp.br

Abstract

Introduction: Facial emotion recognition (FER) is the ability to interpret the feelings and emotions of others. Given the decline in FER ability observed in older adults, intervention studies to assess the effects of training this skill are essential. Therefore, this study aims to evaluate the effects of FER training in cognitively unimpaired older adults.

Method: A randomized, crossover clinical trial was conducted. Twenty-two individuals aged 60 years or older, without indications of depression or cognitive decline, were selected. Participants completed one session of FER training and one control training session through a Matching-to-Sample (MTS) procedure on a portable touchscreen computer, with a seven-day interval between sessions.

The primary outcomes were total accuracy and accuracy by emotion in two FER tasks, using dynamic and static stimuli.

Results: In the dynamic stimuli task, repeated-measures ANOVA revealed significant differences in overall emotion accuracy ($F_{2,40} = 4.592$; $p = 0.016$; $\eta^2p = 0.187$). Bonferroni post hoc analysis indicated improvement following FER training compared to baseline ($p = 0.004$). Additionally, ANOVA showed improved recognition of happiness ($F_{2,40} = 7.732$; $p = 0.001$; $\eta^2p = 0.279$) following FER training compared to control training. Regarding the static stimuli task, ANOVA revealed significant differences in scores only for disgust ($F_{2,40} = 5.748$; $p = 0.006$; $\eta^2p = 0.223$), with improvement following FER training compared to baseline ($p = 0.005$).

Conclusion: FER training increased overall performance accuracy, particularly for happiness and disgust. Future studies involving multiple training sessions, larger sample sizes, and clinical populations are essential for the generalization of these findings.

Keywords: Emotions, facial recognition, aged, social cognition, cognitive aging, cognitive training.

Introduction

Facial emotion recognition (FER) is an essential skill within the domain of social cognition, enabling individuals to interpret emotions through others' facial expressions, thus facilitating communication and social interaction.[1] Basic emotional expressions are considered universal stimuli for emotional communication, as demonstrated in Ekman's classical studies, which identified six basic emotions: happiness, sadness, anger, fear, disgust, and surprise.[2,3]

With aging, evidence suggests that the capacity for FER may become impaired.[4] This decline may be partly explained by structural and functional changes in brain regions such as the amygdala and prefrontal cortex, which are critical for emotional processing.[4–6] Moreover, older adults may have greater difficulty recognizing low-intensity emotional expressions,[7] and performance can be influenced by task-related factors such as stimulus type (i.e., static or dynamic) and the choice of facial stimuli set.[8] Recent evidence from our group also indicates that even older adults without mood or cognitive impairments may

exhibit subtle deficits in FER, underscoring the importance of developing interventions aimed at maintaining this ability throughout healthy aging.[7]
Another factor influencing FER is the presence of neuropsychiatric disorders. Older adults with depression or dementia often exhibit more pronounced impairments in emotion recognition, which can negatively affect social functioning and increase the risk of isolation.[9–11] Despite this, there is a notable lack of studies specifically investigating FER training in this population. Most existing interventions have been developed for individuals with autism spectrum disorder or schizophrenia.[12,13]

A learning paradigm that can be used to train FER skills is the Matching-to-Sample (MTS) procedure. In this paradigm, a sample stimulus is presented to the participant, followed by a set of comparison stimuli from which the correct match must be selected across successive trials. These trials enable the teaching of conditional relations between stimuli [14] and the strengthening of relations that were not previously trained. Three key properties are essential in this model: reflexivity, symmetry, and transitivity. Reflexivity refers to matching identical stimuli without direct training (A→A). In symmetry, the conditional relation is preserved even when the sample and comparison stimuli are reversed (if A→B, then B→A). Finally, transitivity refers to the emergence or generalization of a relation that has not been directly trained (if A→B and B→C, then A→C).[15]

Thus, the aim of this study was to evaluate the effects of an FER training in cognitively unimpaired older adults, using conditional discrimination procedures to promote generalization in FER. Testing the protocol in a non-clinical population provides an important opportunity to establish baseline performance, estimate initial effect sizes, and refine procedures before applying the intervention to clinical populations with more pronounced FER impairments, such as those with depression or dementia.

Method

Design and Participants

The study was conducted at a community center for older adults located in a city in the interior of São Paulo State, Brazil. A randomized crossover clinical trial design was used, in which 22 older adults were randomly allocated using simple randomization to begin either the FER training or the control training, with a seven-day interval between sessions. The protocol was approved by the Research Ethics Committee (CAAE: 17176019.8.0000.5504), and all participants provided written informed consent.

Sample Size Calculation

The sample size was estimated based on normative data from FER performance by Kessels et al.,[16] considering a statistical power of 80% and a significance level of 0.05. A 30% improvement in performance was expected following training. Taking into account a potential 10% attrition rate, the target sample size was set at 20 participants.

Inclusion and Exclusion Criteria

Inclusion criteria were: (i) age 60 years or older; (ii) scores above the education-adjusted cutoff on the Mini-Mental State Examination (MMSE), indicating the absence of cognitive decline;[17] and (iii) a score below 5 on the 15-item Geriatric Depression Scale (GDS-15), indicating the absence of depressive symptoms.[18] Individuals with severe visual or hearing impairments that could interfere with task comprehension, as well as those with serious clinical comorbidities affecting communication, were excluded.

Instruments

FER Task with Dynamic Stimuli - This task, standardized by Kessels et al.,[16] assesses six basic emotions (happiness, sadness, disgust, anger, fear, and surprise) using short video clips in which a neutral facial expression gradually evolves into an emotional expression at varying intensities (40%, 60%, 80%, and 100%). The videos range from 1 to 3 seconds in duration, depending on the number of frames and intensity, and the full task comprises 99 videos, with the first three serving as practice trials. The total score ranges from 0 to 96, with a maximum of 16 points per emotion and 24 points per intensity level. Participants were asked to identify the emotion that best matched each image, with no time constraints. The total administration time is approximately 10 minutes.

FER Task with Static Stimuli - This task was developed using the OpenSesame 3.1 software[19] and consists of 48 black-and-white images of male and female faces, each portraying one of the six basic emotions at either 50% or 100% intensity. The facial expressions were based on the set proposed by Ekman and Friesen.[20] Participants were asked to identify the emotion that best matched each image, with no time constraints. A maximum of eight points can be obtained for each emotion and up to 24 points for each intensity level. The total score ranges from 0 to 48, with eight images per emotion.

Mini-Mental State Examination (MMSE) - The MMSE is a widely used screening tool for cognitive decline, assessing memory, orientation, attention, language, and visuoconstructive abilities.[21] Test–retest reliability coefficients for both cognitively intact and impaired individuals generally range from 0.80 to 0.95, with the highest internal consistency (α = 0.96) observed in mixed medical samples and more modest levels (α = 0.68–0.77) reported in community-based studies.[22] In the Brazilian population, education-adjusted cutoff scores have shown adequate sensitivity and specificity for detecting cognitive impairment: 20 points for illiterate individuals, 22 for those with 1–4 years of education, 24 for 5–8 years, and 26 for individuals with 9 or more years of education.[17]

Geriatric Depression Scale (GDS-15) - The GDS-15 is a screening instrument designed to detect depressive symptoms in older adults and has been validated for Brazilian older adults.16 The original version of the scale demonstrated excellent internal consistency (Cronbach's α = 0.94) and strong test–retest reliability (r = 0.85).20 In the present study, a cutoff score of fewer than five points was used to indicate the absence of clinically relevant depressive symptoms.[18,23] This cutoff point has shown sensitivity of 85.4% and specificity of 73.9% for the diagnosis of major depressive episodes in the Brazilian context.[18]

FER training procedure

The FER training was developed using the OpenSesame 3.1 software, focusing on the three negative emotions that are least accurately recognized by older adults - sadness, anger, and fear - based on the normative data.[16] The facial expressions were selected from the set developed by Ekman and Friesen,[20] comprising a total of six faces, with one male and one female face for each emotion. Importantly, the faces used in the training were different from those presented in the FER task with static stimuli.

The FER and control training procedures were structured into six blocks using MTS paradigm, as outlined in Table 1. Stimuli were presented on a portable touchscreen computer. Each trial began with a sample stimulus - either a facial expression or an emotion label - displayed in the upper half of the screen, followed by three comparison stimuli in the lower half. Participants were asked to select the correct match. With the exception of the final block, correct responses were reinforced with colored stars (feedback), while incorrect responses triggered a blank screen (no feedback). Feedback remained on the screen for one second before the task automatically proceeded to the next trial. Prior to each block, participants received brief and clear instructions regarding the task to be performed.

Each emotion/relation was trained 12 times, totaling 36 trials per block. To progress through the training blocks, participants were required to achieve at least 90% accuracy (33 correct responses). Block 1 (AA) focused on reflexivity. A facial expression at 100% intensity (sample stimulus) was presented on the screen, followed by three comparison stimuli—facial expressions of the same emotion. The participant was instructed to select the face that matched the sample. Blocks 2 (AB) and 4 (AC) trained baseline relations. In block 2, a facial expression at 100% intensity was presented as the sample stimulus, and participants selected the corresponding emotion label from three options displayed below. In Block 4, the sample stimulus was a facial expression at 100% intensity, and the comparison stimuli were facial expressions of the same emotion at 50% intensity; participants selected the expression that best represented the sample. Blocks 3 (BA) and 5 (CA) addressed symmetry training. In Block 3, the sample was an emotion label, and the comparison stimuli were facial expressions at 100% intensity. In block 5, the sample was a facial expression at 50% intensity, and the comparison stimuli were facial expressions at 100% intensity. Block 6 (BC) assessed transitivity. In this final block, a facial expression at 50% intensity was presented as the sample stimulus, and participants had to select the correct emotion label from three options that best represented the facial expression. To control positional bias, the location of the comparison stimuli was randomized across trials.

Table 1: Sequence of task blocks, presence of feedback, involved relations, number of trials per block, and minimum accuracy rate to proceed to the next block in FER and control training.

Block	Procedure	Relations	Feedback	Total of trials	Accuracy rate
1	Reflexivity Training Emotion/Figure 100% - Emotion/Figure 100%	AA	Yes		
2	Baseline Training Emotion/Figure 100% - Label	AB	Yes	36	90%
3	Symmetry Training Label - Emotion/Figure 100%	BA	Yes	36	90%
4	Baseline Training Emotion/Figure 100% - Emotion/Figure 50%	AC	Yes	36	90%
5	Symmetry Training Emotion/Figure 50% - Emotion/Figure 100%	CA	Yes	36	90%
6	Transitivity Test Emotion/Figure 50% - Label	BC	No	36	-

The control training was also developed using the OpenSesame 3.1 software and followed the same structure as the FER training. However, instead of facial expressions, it employed neutral images taken from the Microsoft Office 2017 (Word) icon set, including two houses, two trees, and two shoes; corresponding to the six facial stimuli used in the FER training. To simulate the intensity variation used in the FER task, the number of pixels in each image was reduced so that the 50% pixel version approximated a 50% intensity level. For each category (trees, houses, and shoes), two distinct images were selected - paralleling the use of male and female faces - thus preserving the structural design of the FER training.

Procedures

Forty individuals who regularly attended activities at the community center were invited to participate in the study. Of these, eleven declined to participate and seven were excluded based on their MMSE and GDS scores. The final sample consisted of 22 eligible volunteers.

After confirming eligibility, participants completed a structured sociodemographic questionnaire and underwent baseline assessment using both the static and dynamic FER tasks. One week later, participants were randomly assigned to begin with either the FER training or the control training, followed by both FER tasks. The order of conditions was counterbalanced across participants and determined through simple randomization to minimize potential order effects. After another seven days, the groups switched conditions: those who initially received the FER training then completed the control training, and vice versa. All assessments and training sessions were conducted in a quiet and appropriate room. Each session lasted approximately 60 minutes.

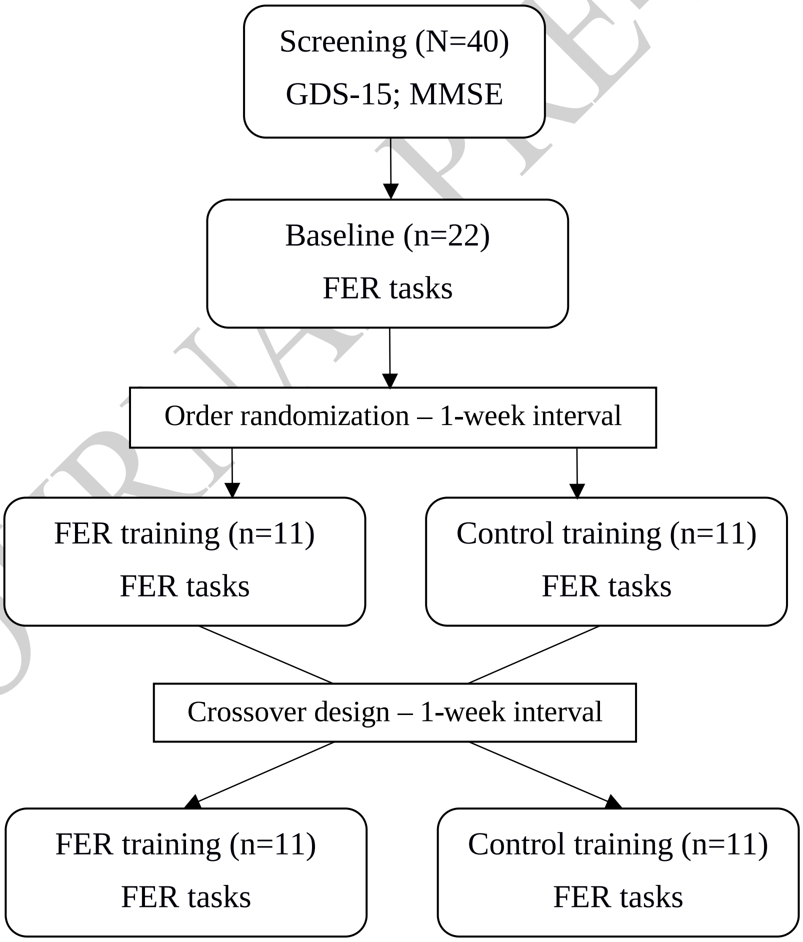

Figure 1: Schematic representation of the within-subject (crossover) experimental design.

Statistical Analysis

Descriptive analyses of sociodemographic data were conducted using percentages, means, and standard deviations. Of the 42 observations corresponding to 14 FER-related variables, comprising two total scores and six emotion-specific scores for each FER task, 33 showed normal distributions according to the Kolmogorov-Smirnov test. Repeated-measures ANOVA was conducted with three levels: baseline, FER training, and control training as the within-subject factor. This test was applied because repeated-measures ANOVA is considered robust to moderate violations of the normality assumption, particularly in balanced designs and within-subject comparisons.[24] When the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied to adjust the degrees of freedom. Effect sizes were reported as partial eta squared (η^2p). Bonferroni-adjusted post hoc tests were performed for pairwise comparisons across time points, as this conservative correction method effectively controls the familywise type I error rate when multiple comparisons are conducted. All analyses were performed using SPSS version 21.0, with the significance level set at $p < 0.05$.

Results

Regarding sociodemographic characteristics, the sample consisted predominantly of older women (n = 20), most of whom were retired (n = 18). Marital status was as follows: fourteen participants were married, nine were widowed, one was single, and one was divorced. The mean age was 70.04 years (SD = ±4.79), and the mean educational level was 6.72 years (SD = ±4.16). The average MMSE score was 27.40 (SD = ±1.81). One participant did not complete all experimental sessions and was excluded from the outcome analysis of the FER tasks presented below.

Table 2. Sociodemographic and clinical characteristics of participants.

Variables (N = 22)	Mean ± SD or n (%)
Sociodemographic variables	
Age (years)	70.04 ± 4.79
Education (years)	6.72 ± 4.16
Sex, female n (%)	20 (90.9)
Marital status	
Married	14 (63.6)
Widowed	6 (27.3)
Divorced	1 (4.5)
Single	1 (4.5)
Retired	18 (81.8)
Clinical characteristics	
MMSE score	27.40 ± 1.81
GDS-15 score	1.59 ± 1.82

SD = standard deviation; MMSE = Mini-Mental State Examination; GDS-15 = Geriatric Depression Scale – 15 items.

In the FER training, only the BC block (transitivity) was presented without feedback. In this block, only one participant scored below 60% accuracy, while two-thirds of the sample achieved over 80% correct responses.

Dynamic Stimuli Task

The repeated-measures ANOVA revealed statistically significant differences in overall task accuracy ($F_{2,40} = 4.592$; $p = 0.016$; $\eta^2p = 0.187$). Bonferroni post hoc analysis indicated a significant improvement following FER training compared to baseline ($p = 0.004$).

Regarding the emotion of happiness, the ANOVA also showed significant differences ($F_{2,40} = 7.732$; $p = 0.001$; $\eta^2p = 0.279$), with post hoc comparisons revealing higher accuracy after FER training compared to the control training ($p = 0.001$).

For the emotion of anger, repeated-measures ANOVA revealed significant differences across the three assessments ($F_{2,40} = 11.710$; $p < 0.001$; $\eta^2p = 0.369$). Post hoc analysis indicated significant differences between baseline and both the FER training ($p < 0.001$) and the control training ($p = 0.016$).

Regarding disgust, the ANOVA showed a significant main effect ($F_{2,40} = 3.315$; $p = 0.047$; $\eta^2p = 0.142$), although post hoc comparisons did not reach statistical significance. There was, however, a trend toward improvement between baseline and FER training ($p = 0.060$). No significant differences were found for the remaining emotions.

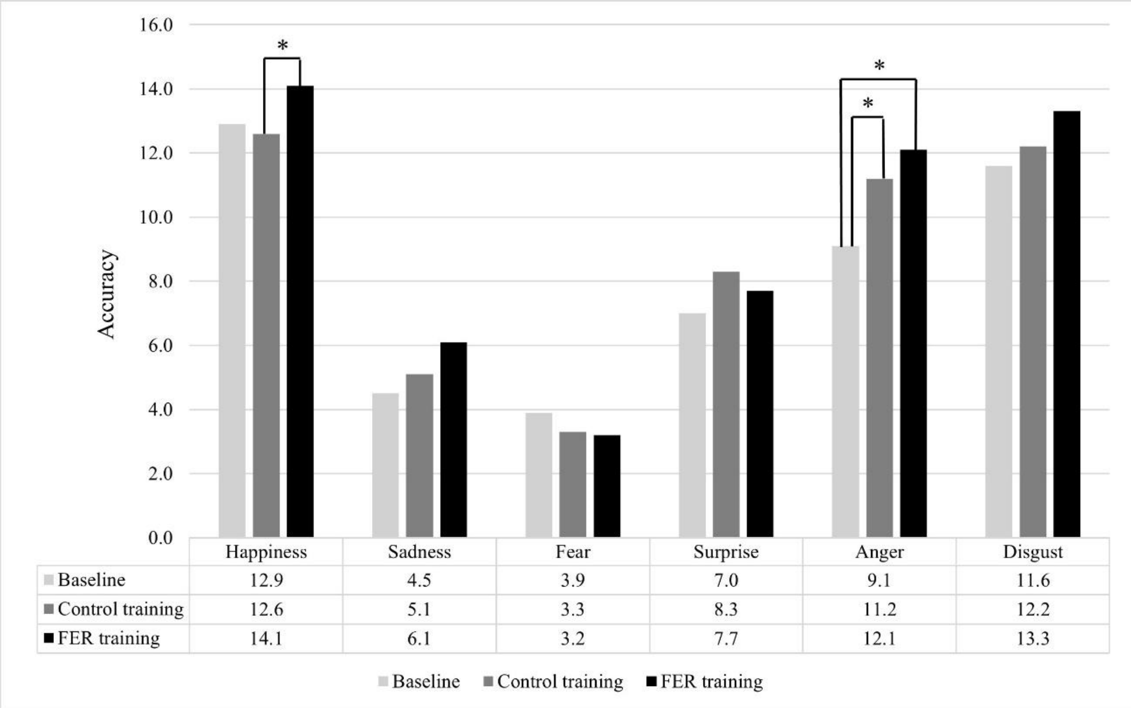

Figure 2. Mean accuracy scores in the dynamic FER task by emotion across baseline, FER training, and control training. *: p < 0.05.

Static Stimuli Task

The repeated-measures ANOVA revealed statistically significant differences in overall task performance ($F_{2,40} = 6.206$; $p = 0.004$; $\eta^2p = 0.237$). Bonferroni post hoc analysis showed significant differences between baseline and both the FER training ($p = 0.007$) and the control training ($p = 0.026$).

Regarding individual emotions, significant differences were found only for disgust ($F_{2,40} = 5.748$; $p = 0.006$; $\eta^2p = 0.223$), with post hoc analysis indicating higher accuracy following FER training compared to baseline ($p = 0.005$). No significant differences were observed for the other emotions.

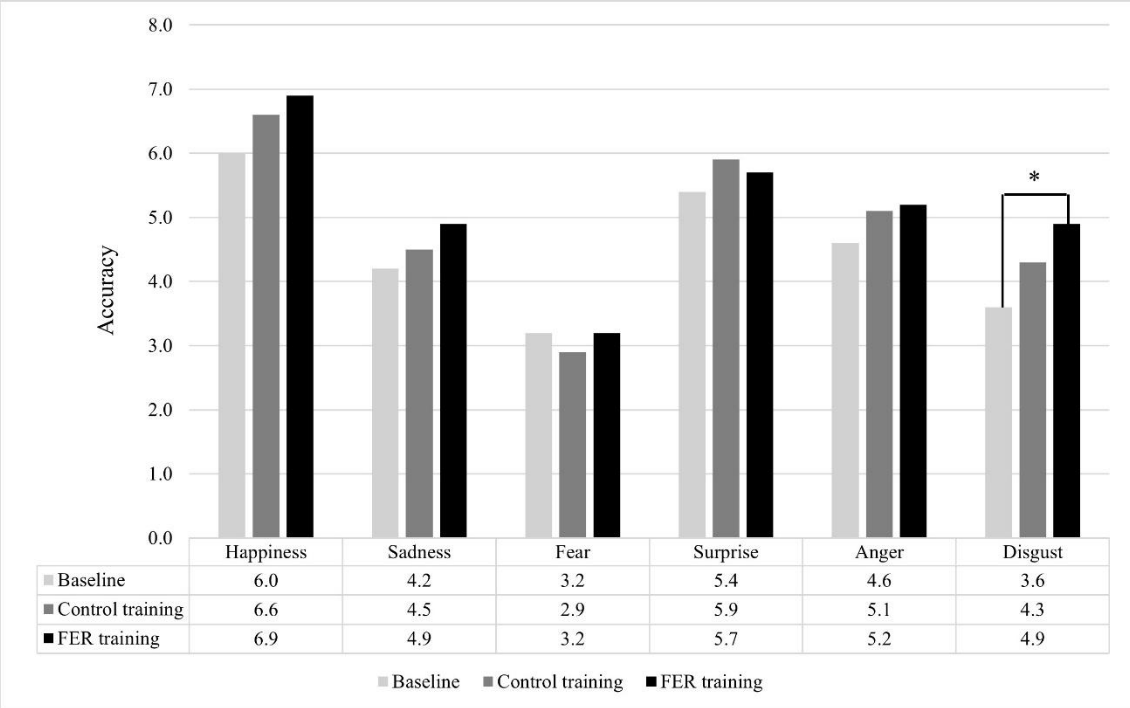

Figure 3. Mean accuracy scores in the static FER task by emotion across baseline, FER training, and control training. *: $p < 0.05$.

Discussion

The present study aimed to evaluate the effects of a FER training program through a generalization process in cognitively unimpaired older adults. Overall, participants showed improved performance on FER tasks following the training, particularly in overall accuracy, recognition of happiness in the dynamic stimuli task, and disgust in the static stimuli task.

Several other studies have investigated FER training in different populations and have reported improvements in performance.[13,25,26] However, these studies generally involved multiple training sessions,[27] in contrast to the single-session approach used in the present study. It is also important to highlight that their samples included individuals with schizophrenia, autism, or traumatic brain injury - conditions that may hinder the learning process. Additionally, the present study employed a task that was simple to implement, highly applicable, and low-cost, unlike other studies that relied on virtual reality or more complex training protocols.[28,29]

A study conducted with cognitively unimpaired adults reported improvements in the recognition of both neutral and anger faces. The training program used in that study encompassed the full domain of social cognition, including FER.[1] Similarly, the present study showed increased accuracy for specific emotions. Notably, recognition of anger also improved after FER training compared to baseline. However, a significant difference was also observed between baseline and control training, which complicates the interpretation of this result. One possible explanation is that all participants completed both the FER and control training sessions, with only the order being counterbalanced. Therefore, it is not possible to determine how long the observed improvement in performance persisted after the training. Furthermore, since the outcome tasks were always administered after the training sessions, participants were repeatedly exposed to emotional facial expressions, which may have led to increased familiarity and influenced performance on subsequent tasks.

Another interesting finding was the improvement in the recognition of non-trained emotions, which may suggest learning by exclusion. In this study, the MTS training paradigm targeted only three emotions (i.e. sadness, fear, and anger). However, post-training differences were statistically significant for happiness and disgust. This pattern may reflect exclusion-based learning mechanisms inherent to the MTS paradigm, in which participants learn conditional relations that can give rise to emergent or generalized associations among stimuli not directly trained.[14,15,25,30] Such processes are consistent with the formation of stimulus equivalence classes, allowing transfer of learning across related emotional categories. Another possible explanation is that these emotions are inherently easier to recognize.[8] The use of a single training session may have primarily facilitated the recognition of emotions that are more readily identifiable. Future studies incorporating multiple training sessions could help address this question and provide a more comprehensive evaluation of performance across other emotions.

An important finding was the low performance in recognizing fear and sadness, observed in both the dynamic and static FER tasks. It is worth noting that the facial stimuli used in the static task were drawn from the same face database used to construct the FER training, which may have contributed to slightly better performance in that task. In the dynamic task, baseline accuracy for fear and sadness was below 30%, highlighting the difficulty older adults experience in recognizing these emotions, possibly explaining the limited improvement even after training. These findings are consistent with a previous review conducted by our group, which also reported low FER accuracy in older populations, even among cognitively healthy individuals. This raises the question of whether the difficulty is inherent to emotion recognition or partly attributable to the use of nonspecific assessment methods.[7]

Finally, it is important to emphasize that overall performance improved in both tasks following FER training compared to baseline. However, in the static stimuli task, a significant difference was also observed between baseline and control training. This finding may be explained by the fact that the stimuli used in both the training and the static task were drawn from the same database, despite involving different actors' faces. Greater exposure to similar facial stimuli may have facilitated learning. Moreover, as previously mentioned, it is not possible to determine whether participants who completed FER training in the first week retained the learning effects when undergoing the control training in the second week - an inherent limitation of the crossover design employed in this study.

Other limitations of the study include the small sample size, which was predominantly composed of women with less than eight years of formal education, making it difficult to generalize the findings. Previous studies have reported that women tend to outperform men in FER tasks, possibly due to greater emotional expressivity and sensitivity to social cues.[31] Considering that our sample consisted predominantly of women, our results cannot be generalized to both sexes. Moreover, as women generally exhibit superior performance in FER, this higher baseline ability could have limited the detection of further improvements when overall performance is already high. In addition, the FER training included only three basic emotions, which may have contributed to the modest improvements observed. Another limitation is the lack of a follow-up assessment, which would be valuable to determine whether the observed effects are sustained over time. Moreover, although different stimulus sets and counterbalanced condition orders were used as attempts to minimize familiarity or practice effects due to repeated exposure to facial stimuli, this possibility cannot be completely ruled out and therefore remains a limitation of the study. The fixed order of tasks, always administered after the training sessions, may have introduced exposure bias. However, the static FER task and the training were based on the same facial stimuli database but involved different actors in each condition, minimizing direct repetition. In addition, the dynamic FER task employed a distinct database, which further reduces the likelihood of familiarity or visual similarity effects.

Nevertheless, it is important to emphasize the relevance of this study in demonstrating improvements in FER performance using a single-session training based on the MTS paradigm, considering the well-documented decline in social cognition, particularly in FER, among older adults, even in the absence of psychiatric or neurocognitive disorders. In this context, a brief, single-session FER training represents a feasible and low-cost approach that can be easily implemented in clinical or community settings. This type of intervention may help preserve emotional understanding, communication, and interpersonal functioning, domains often affected during aging. It is also worth noting that many multidomain interventions designed for both clinical and non-clinical populations do not include specific components targeting social cognition. Therefore, the present intervention could serve as a complementary and time-efficient tool to enhance this domain in older adults. Moreover, by demonstrating measurable improvements after a single session, this study helps address a gap in the literature, as most existing interventions targeting social cognition are lengthy, resource-intensive, and primarily focused on clinical populations such as individuals with schizophrenia or autism spectrum disorder.

Conclusion

FER training using the MTS paradigm increased overall accuracy in emotion recognition, particularly in the dynamic stimuli task and the recognition of happiness and disgust. This study employed a single training session, and future research involving multiple sessions will be essential to better assess learning across a broader range of emotions. Furthermore, applying FER training to clinical populations may provide important insights into its potential impact on outcomes such as quality of life, well-being, and psychological functioning.

Disclosure

No conflicts of interest declared concerning the publication of this article.

Acknowledgments: This study was financed in part by the Brazilian fostering agency Coordination for the Advancement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES), finance code 001. M.H.N.C. is the recipient of a CNPq Research Productivity Fellowship (process no. 309870/2025-9). A.J.L.B. was a recipient of a scholarship from the CAPES. L.L.P. was a recipient of a scholarship from the FAPESP (process no 2020/08347-3). B.L.C.F was a recipient of a scholarship from the National Council for Scientific and Technological Development - CNPq (process no 130299/2019-7).

Authors' Contributions: M.H.N.C., B.L.C.F. and A.J.L.B. contributed to the study conception and design. M.H.N.C. and B.L.C.F. wrote the first draft of the article. M.H.N.C. and A.J.L.B. supervised the study. B.L.C.F and L.L.P. collected the data. All authors reviewed, edited the article and approved the final version.

Handling Editor: Leticia Czepielewski

References

1. Schoeneman Patel SE, Chrobak AA, Rodrigues PM, Xu T, Hill SK. Social cognition training improves recognition of distinct facial emotions and decreases misattribution errors in healthy individuals. Front Psychiatry. 2022;13:1026418.
2. Ekman P, Cordaro D. What is meant by calling emotions basic. Emotion Rev. 2011;3(4):364–70.
3. Ekman P, Sorenson E, Friesen W. Pan-cultural elements in facial displays of emotion. Science. 1969;164(3875):86–8.

4. Ruffman T, Henry JD, Livingstone V, Phillips LH. A meta-analytic review of emotion recognition and aging: Implications for neuropsychological models of aging. Neurosci Biobehav Rev. 2008;32(4):863–81.

5. Adolphs R, Tranel D. Impaired judgments of sadness but not happiness following bilateral amygdala damage. J Cogn Neurosci. 2004;16(3):453–62.

6. Weiss EM, Kohler CG, Brensinger CM, Bilker WB, Loughead J, Delazer M, et al. Impairment in emotion recognition abilities in patients with mild cognitive impairment, early and moderate Alzheimer's disease compared with healthy comparison subjects. Am J Geriatr Psychiatry. 2008;16(12):974–80.

7. Ferreira BLC, Fabrício DM, Chagas MHN. Are facial emotion recognition tasks adequate for assessing social cognition in older people? A review of the literature. Arch Gerontol Geriatr. 2021;92:104277.

8. Hayes GS, McLennan SN, Henry JD, Phillips LH, Terrett G, Rendell PG. Task characteristics influence facial emotion recognition age-effects: A meta-analytic review. Psychol Aging. 2020;35(3):295–315.

9. Bomfim AJL, Ribeiro RAS, Chagas MHN. Recognition of dynamic and static facial expressions of emotion among older adults with major depression. Trends Psychiatry Psychother. 2019;41(2):159–66.

10. Dourado MCN, Fádel BTM, Neto JPS, Alves G, Alves C. Facial expression recognition patterns in mild and moderate Alzheimer's disease. J Alzheimers Dis. 2019;69(2):539–49.

11. Krause FC, Linardatos E, Fresco DM, Moore MT. Facial emotion recognition in major depressive disorder: A meta-analytic review. J Affect Disord. 2021;293:320–8.

12. Russo-Ponsaran NM, Evans-Smith B, Johnson J, Russo J, McKown C. Efficacy of a facial emotion training program for children and adolescents with autism spectrum disorders. J Nonverbal Behav. 2016;40(1):13–38.

13. Thonse U, Behere RV, Frommann N, Praharaj SK, Sharma PSVN. Efficacy of a culturally adapted emotion recognition training program in improving facial emotion recognition in persons with schizophrenia. Indian J Psychol Med. 2024; doi:10.1177/02537176241281451.

14. Sidman M. Equivalence relations and behavior: A research story. Boston: Authors Cooperative; 1994.

15. De Rose JC. Classes de estímulos: implicações para uma análise

comportamental da cognição. Psicol Teor Pesqui. 1993;9(2):283–303.

16. Kessels RPC, Montagne B, Hendriks AW, Perrett DI, De Haan EHF. Assessment of perception of morphed facial expressions using the Emotion Recognition Task: Normative data from healthy participants aged 8–75. J Neuropsychol. 2014;8(1):75–93.

17. Bertolucci PH, Brucki SMD, Campacci SR, Juliano Y. The Mini-Mental State Examination in a general population: Impact of educational status. Arq Neuropsiquiatr. 1994;52(1):1–7.

18. Almeida OP, Almeida SA. Reliability of the Brazilian version of the abbreviated form of Geriatric Depression Scale (GDS-15). Arq Neuropsiquiatr. 1999;57(2B):421–6.

19. Mathôt S, Schreij D, Theeuwes J. OpenSesame: An open-source graphical experiment builder for the social sciences. Behav Res Methods. 2012;44(2):314–24.

20. Ekman P, Friesen W. Pictures of facial affect. Palo Alto: Consulting Psychologists Press; 1976.

21. Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”: A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189–98.

22. Tombaugh TN, McIntyre NJ. The Mini-Mental State Examination: A comprehensive review. J Am Geriatr Soc. 1992;40(9):922–35.

23. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: A preliminary report. J Psychiatr Res. 1982;17(1):37–49.

24. Blanca MJ, Alarcón R, Arnau J, Bono R, Bendayan R. Non-normal data: Is ANOVA still a valid option? Psicothema. 2017;29(4):552–7.

25. Guercio JM, Podolska-Schroeder H, Rehfeldt RA. Using stimulus equivalence technology to teach emotion recognition to adults with acquired brain injury. Brain Inj. 2004;18(6):593–601.

26. Rawdon C, Murphy D, Dodd AL, Button KS, Browning M, Lewis G, et al. An investigation of emotion recognition training to reduce symptoms of social anxiety in adolescence. Psychiatry Res. 2018;263:257–67.

27. Zhang Q, Wu R, Zhu S, Le J, Chen Y, Lan C, et al. Facial emotion training as an intervention in autism spectrum disorder: A meta-analysis of

randomized controlled trials. Autism Res. 2021;14(10):2169–82.

28. Lado-Codesido M, Pérez CM, Mateos R, Olivares JM, Caballero AG. Improving emotion recognition in schizophrenia with "VOICES": An online prosodic self-training. PLoS One. 2019;14(1):e0210816.

29. Nijman SA, Veling W, Timmerman ME, Pijnenborg GHM. Trajectories of emotion recognition training in virtual reality and predictors of improvement for people with a psychotic disorder. Cyberpsychol Behav Soc Netw. 2023;26(4):288–99.

30. Wilkinson KM, Rosenquist C, McIlvane WJ. Exclusion learning and emergent symbolic category formation in individuals with severe language impairments and intellectual disabilities. Psychol Rec. 2009;59(2):187–206.

31. Thompson AE, Voyer D. Sex differences in the ability to recognise non-verbal displays of emotion: A meta-analysis. Cogn Emot. 2014;28(7):1164–95.