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RESEARCH ARTICLE

COMPUTERIZED OPUS IN NEUROPSYCHOLOGICAL TESTING USING E-APPLICATION OF MULTITASKING PARADIGM (CONTEMP): AN ADVANCEMENT OF NEUROPSYCHOLOGICAL ASSESSMENT & REHABILITATION FOR EARLY DEMENTIA

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ABSTRACT:
Background: A few of cognitive rehabilitation is successful in early dementia (Clare, 2001) which is well documented in previous research; however, there is no as such multitasking rehabilitation that exists nationally. Though, it is reviewed that multitasking might make individual more productive & stimulating (Bannister and Remenyi, 2009). **Objective**: To develop and standardize a ***multitasking module of motor, auditory and visual modality*** which in dementia is usually found to be impaired and document its efficacy. **Method:** Development process included 3 phases: Ist phase: item selection where pictures & sounds were selected as per the commonality factor, where 40 pictures & its respective sounds were selected & were paired up with random and common audible sound. IInd phase: Item discriminatory factor where 18 sound- picture matched & other 18 non-matched picture- sound were finalized as per pilot tryout on 5 patients with Mild Cognitive Impairment & 5 controls. IIIrd phase: standardization was done on 25 MCI & 43 controls. A scoring was finalized on reaction time (in seconds) & recall rate. Standard time & recall rate cut off norms were developed. **Results:** Descriptive analysis was done where total time of paradigm was found to be (4.69±2.32), recall time was (132.53±107.72). recall rate was found out to be (16.79±2.35) thereby giving a base for acceptable multitasking paradigm for dementia group which may further be useful for rehabilitation. **Conclusion:** this multimodality module seems to be a promising paradigm; however, a further neuro-imaging confirmation is required.
KEY WORDS : Mild Cognitive Impairment, CONTEMP, dementia

INTRODUCTION:

In today's information-rich society, people frequently attempt to perform many tasks at once. This often requires them to juggle their limited resources in order to accomplish each of these tasks successfully. This juggling is not always easy, and in many cases can lead to greater inefficiency in performing each individual task. In the brain, juggling multiple tasks ("Multitasking") is performed by mental executive processes that manage the individual tasks and determine how, when, and with what priorities they get performed. These executive processes act like a choreographer who orchestrates many individual dancers so that they can perform as a single unit. However, aging is typically associated with a deterioration of such cognitive ability, including memory, decision-making, multitasking and cognitive control (Fisk and Sharp, 2004; Luo and Craik, 2008; Brown and Ridderinkhof, 2009).

There is no dearth of researches supporting that older people have a more difficult time multitasking not because they have to devote more attention to a secondary task, but because

their brains have a harder time disengaging from the secondary task and going back to the original one. (Makizako.et.al,2011). This has been documented by using functional magnetic resonance imaging (fMRI) where brain activity of 20 older adults (above 60 years of age) and 20 younger adults were analysed & compared and found Unlike younger individuals, older adults failed to both disengage from the interruption and re-establish functional connections associated with the disrupted memory network. (Wesley C. Clapp , 2011).

And such Decline is associated with shrinkage of prefrontal cortex, hippocampus, and basal ganglia (Raz et al., 2005) and alterations in their structural connectivity (O'sullivan et al., 2001; Madden et al., 2009) along with a decrease in synthesis and binding of dopamine, serotonin and acetylcholine (Wang et al., 1995, 1998; Volkow et al., 1998; Bäckman et al., 2006; Schliebs and Arendt, 2010). Together, these structural changes cause neuromodulator levels to drop, affecting important functional pathways, principally in striatal and frontostriatal areas (Bäckman et al., 2006). Thereby impairing the multitasking ability.

Considering the role of brain activity, and the advancement in the field of cognitive rehabilitation, recent international researches highlights the robust plasticity of the prefrontal cognitive functioning in the older adults which suggests that cognitive retraining is possibly useful in improving the multitasking ability of older adults. (J. A. Anguera.et.al 2013)

A recent research proved that computerized cognitive training improves multitasking ability in older adults which showed better performance in sustained attention and working memory, with an increase in midline frontal theta power predicting the training-induced boost in sustained attention and preservation of multitasking improvement in follow up after 6 months. (J. A. Anguera.et.al 2013)

Another research used computerized training program to improve working memory and perceptual ability in older adults with mean age of 71.93 years. Their findings showed remarkable improvement in perceptual ability and their working memory ability which was correlated with electroencephalography. (Berry AS.et.al, 2010)

Moreover, Paul E. Dux.et.al, 2012 showed how cognitive training works on prefrontal cortex thereby reducing the multitasking costs in older adults. According to his study, reduction of multitasking interference with training is not achieved by diverting the flow of information processing away from the prefrontal cortex or by segregating prefrontal cells into independent task-specific neuronal ensembles, but rather by increasing the speed of information processing in this brain region, thereby allowing multiple tasks to be processed in rapid succession. These results not only reveal how training leads to efficient multitasking, they also provide a mechanistic account of multitasking limitations, namely the poor speed of information processing in human prefrontal cortex. (Paul E. Dux.et.al, 2012)

There are also researchers stating that cognitive retraining of executive function using video game slows down the cognitive decline. In their study, older adults were trainined in a real-time strategy video game for 23.5 hr in an effort to improve their executive functions. A battery of cognitive tasks, including tasks of executive control and visuospatial skills, were assessed before, during, and after video-game training. The trainees improved significantly in the measures of game performance. They also improved significantly more than the control participants in executive control functions, such as task switching, working memory, visual short-term memory, and reasoning. Individual differences in changes in game performance were correlated with improvements in task switching. (Basak.et.al 2008)

However, there is no as such literature available on Indian population. Hence, the attempt was made to develop and standardize a custom-designed multitasking cognitive module for older adults which is education and culturally appropriate for Indian population. The developed multitasking module provide the first evidence, nationally, to assess cognitive

abilities across the lifespan, to evaluate underlying neural mechanisms, and serve as a powerful tool for cognitive enhancement

METHODOLOGY

Participant's characteristics: all the participants (N=68) were between 50-78 years of age, both males and females (Males = 36 & Females =32), right and left handed individuals who had elementary education to understand the instructions were recruited in the study.

Inclusion criteria for Participant's

- Consenting individuals & willing to participate in the study
- Participants neurologically diagnosed as having Mild Cognitive Impairment & early Dementia was taken up as patient group.
- Participants having no subjective memory issues were taken up as control group
- Ability to comprehend the instructions
- Had adequate Visual and auditory acuity

Exclusion criteria for Participant's

- Non consenting individuals
- Participants neurologically diagnosed as having moderate or severe dementia
- Participants with visual and hearing difficulty
- Any significant psychiatric illness or substance induced conditions.
- Participants with hemiplegia or hemi-paresis

Inclusion criteria for module items

- Black & white picture
- Picture clarity
- Common & familiar picture & sound
- Normal audible sound

Exclusion criteria for module items

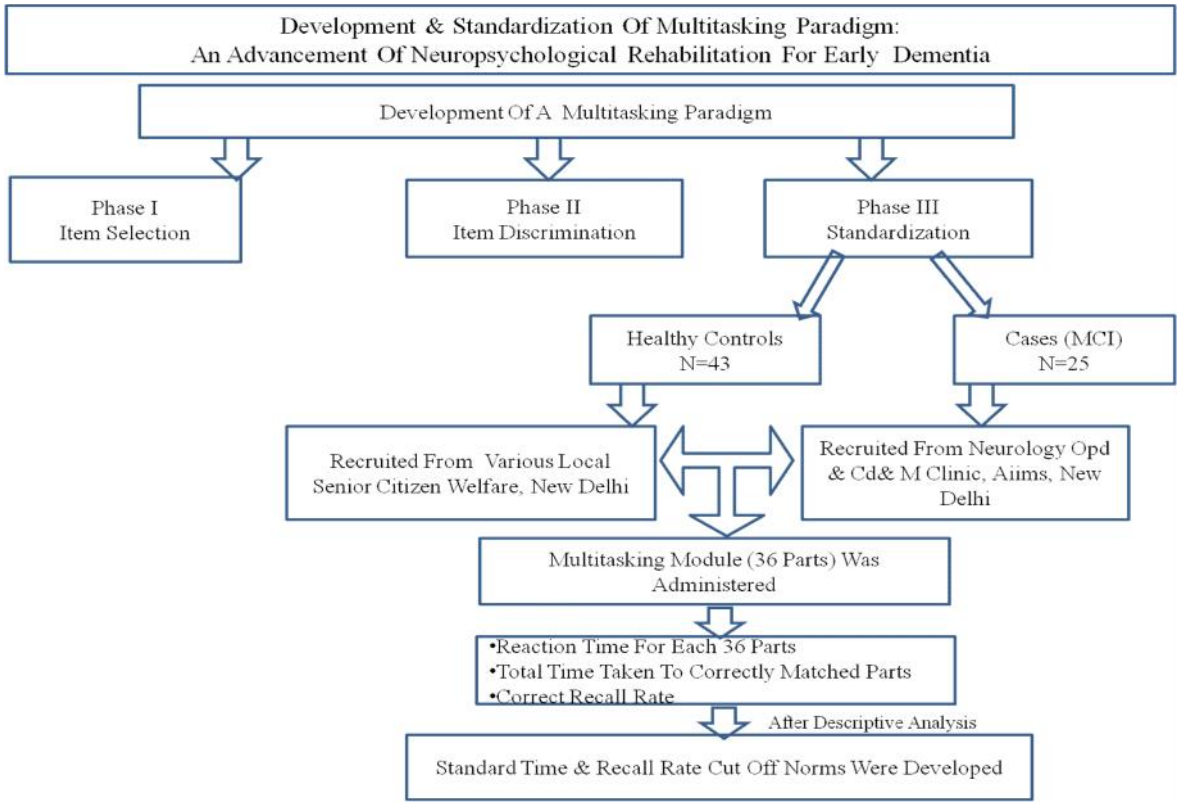
- Coloured pictures
- Unclear sound
- Abstract pictures

Study design

The present study was done in 3 phases, the first and the second phase involved the Development of a multitasking module while the third phase involved the standardization process. The details of the each phases is as following:-

- **Ist phase**: it is item selection phase where pictures & sounds were selected as per the commonality factor, (i.e based on the most heard and seen pictures and sounds in the Indian culture) where 40 pictures & its respective sounds were selected & were paired up with random and common audible sound.
- **IInd phase**: it is the Item discriminatory factor (i.e to what extent the sound and pictures are different and discriminating against each other) where 18 matched sound- pictures & other 18 non- matched picture- sound were finalized as per pilot tryout on 5 patients with Mild Cognitive Impairment patients & 5 healthy controls.
- **IIIrd phase:** it is the standardization process which included administration of the module and developing the norms for each group. The module was administered on 25 MCI & 43 healthy controls. For each 36 parts (18 matched sound- pictures & other 18 non- matched picture- sound) reaction time (in seconds) was noted down along with the overall time taken to complete the module and the recall rate to correctly recall the matched sound-picture part.

Descriptive analysis was done, and hence, standard time & recall rate cut off norms were developed for each group.



Administration Instructions

In English: You will be presented with some pictures and sounds, you have to click the 'YES' button with your preferred finger whenever a picture and its respective sound match & 'NO' when it does not match as fast as possible. Also try and remember those pictures whose sound matched as you have to speak those names in any order in the end. Are you ready?

In Hindi: हम आपको कुछ चित्र दिखायेगे और कुछ आवाज़े सुनाएँगे। आपको उन चित्रों पर क्लिक करना है जिन चित्रों की आवाज़ उनसे मेल खाती है और कोशिश करनी है उन्हें याद रखने की क्यूंकि आपको आखिर में उन चित्रों के नाम बताने होंगे। किसी भी आर्डर में बता सकते है। क्या आप तैयार है?

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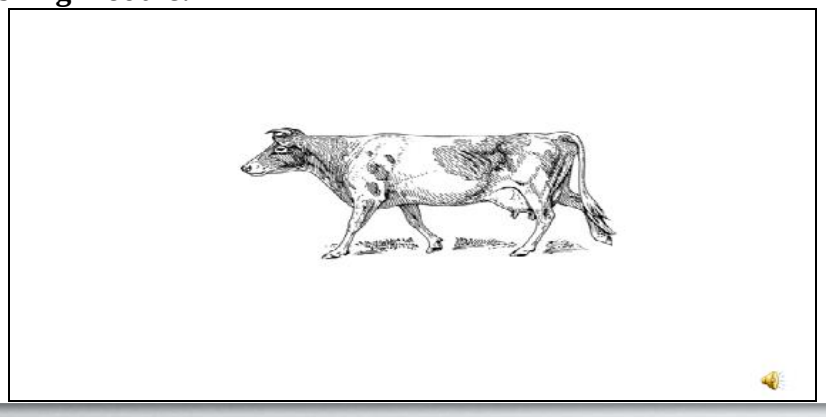
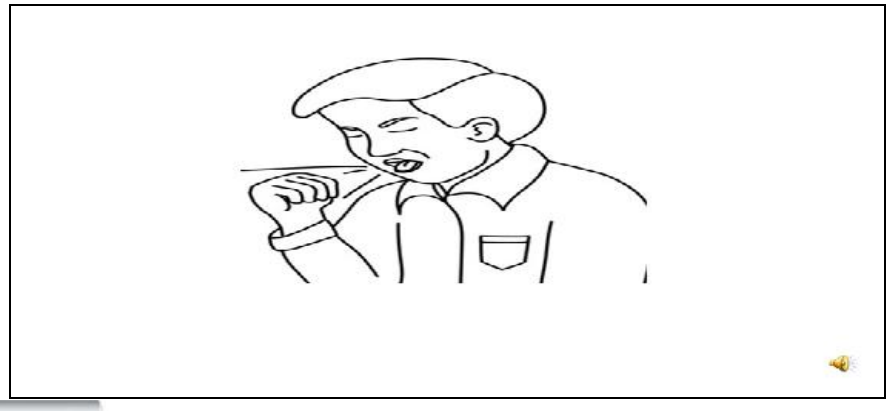
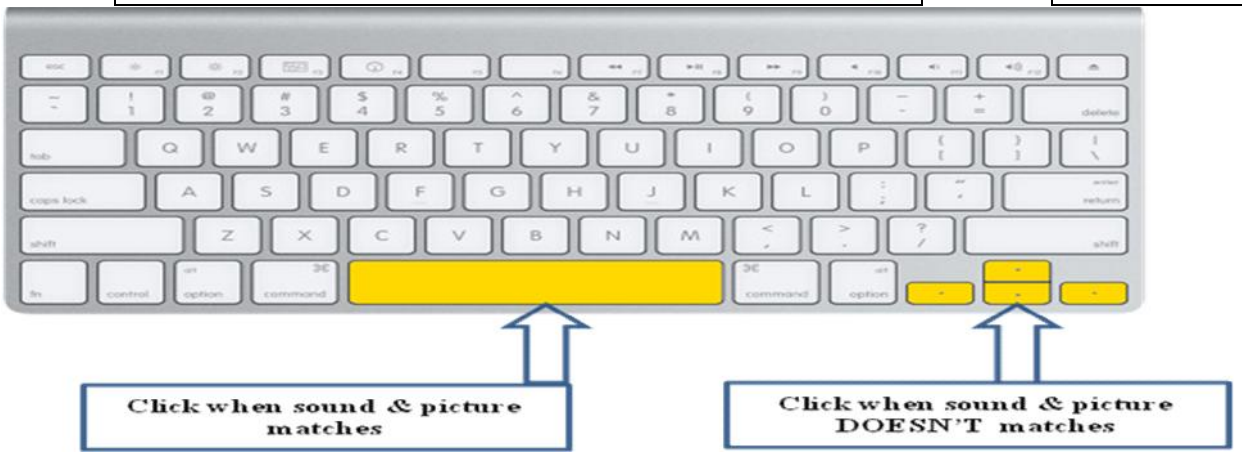
Multitasking module:







Results:

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Table 1

PATIENT GROUP																																							
	Part Number																																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Total Time to complete	Total Time to recall	Correct Recall rate
Mean	3	6.28	3.96	2.96	5.12	4.6	6.92	6.12	4.92	3.68	5.56	9.6	5.72	3.32	4.2	4.16	4.24	7.0	4.28	5.96	6.88	3.16	4.64	6.52	6.2	4.56	6.92	4.96	6.36	5.84	5.32	4.68	4.72	6.04	5.36	6.0	6.00	127.76	14.52
S.D	1.57	8.36	3.97	2.42	2.89	4.84	4.98	4.29	5.54	3.37	6.03	7.87	5.22	2.29	4.35	6.36	2.84	4.58	7.68	3.66	6.68	5.19	3.56	6.21	2.82	5.20	7.16	2.92	6.18	4.54	4.29	3.68	2.90	5.27	4.24	4.14	4.4	45.30	2.69

The above table depicts the reaction time of the patient group (N=25) in all the parts of the paradigm (36 parts) along with the total time taken to complete the paradigm, total time to recall the correct or matched picture and sound and the correct recall rate. All the values are given in the mean and standard deviation. The reaction time in all 36 parts, total time to recall the correct or matched picture and sound and the correct recall rate is recorded in seconds, while the total time to complete the paradigm is recorded in minutes. Apart from this, the correct rate is calculated from the total correct matched picture and sound parts (i.e, 18).

Hence, the patient group took 6 $\pm$ 4.4 minutes to complete the paradigm. While they took 127.76 $\pm$ 45.30 seconds to recall the correct or matched picture and sound with 14.52$\pm$ 2.69 seconds correct recall rate.

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Table 2

HEALTHY CONTROLS GROUP																																						
	Part Number																																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Total Time to complete	Total Time to recall	Correct Recall rate
Mean	2.86	3.34	3.74	3.20	4.74	3.06	4.13	4.23	3.77	3.65	4.98	4.60	4.81	4.51	4.32	3.83	4.13	4.81	4.69	3.56	3.97	3.11	4.65	4.11	4.58	3.27	4.52	5.34	4.27	3.53	3.81	3.18	3.76	4.69	3.97	4.69	4.69	132.53	16.79
S.D	1.29	1.34	2.15	1.67	2.32	1.14	3.02	2.77	2.49	2.45	3.30	3.20	3.18	2.40	2.04	2.09	2.06	3.21	3.52	2.52	2.19	1.45	2.89	2.02	2.01	2.11	2.71	4.29	2.07	1.54	1.93	1.63	1.99	2.94	3.02	2.27	2.32	107.72	2.35

The above table depicts the reaction time of the healthy controls group (N=43) in all the parts of the paradigm (36 parts) along with the total time taken to complete the paradigm, total time to recall the correct or matched picture and sound and the correct recall rate. All the values are given in the mean and standard deviation. The reaction time in all 36 parts, total time to recall the correct or matched picture and sound and the correct recall rate is recorded in seconds, while the total time to complete the paradigm is recorded in minutes. Apart from this, the correct rate is calculated from the total correct matched picture and sound parts (i.e, 18).

Hence, the patient group took 4.69 ± 2.32 minutes to complete the paradigm. While they took 132.53 ± 107.72 seconds to recall the correct or matched picture and sound with 16.79± 2.35 seconds correct recall rate.

DISCUSSION

In such a fast pacing world, Multitasking ability has become a necessity to sustain a better life in all domains of life irrespective of the age. Though researches suggest that older people have a more difficult time multitasking not because they have to devote more attention to a secondary task, but because their brains have a harder time disengaging from the secondary task and going back to the original one (Makizako.et.al, 2011). But due to modern technological innovation in the field of neuropsychological rehabilitation, recent researches came up with cognitive training programs which are increasingly being developed to remediate age-related deficits including the higher level cognitive functions such as perceptual abilities, multitasking abilities and working memory. (Mahncke HW.et.al, 2006).

Internationally, Researchers found that seniors who play a 3-D video game improve their ability to sustain focus and multitask successfully. To test whether older adults could improve multitasking ability, the researchers randomly assigned 46 healthy adults, ages 60 to 85, to 1 of 3 groups: multitask training using the 3-D videogame, single-task training using a similar videogame, or no videogame training. During multitask training; participants used a joystick to maintain a moving car in the centre of a winding road while also responding to road signs that popped up. As participants improved, the games got harder.

Seniors who played the multitasking game on a laptop at home for 1 hour a day, 3 times a week for 4 weeks (12 hours of total training) significantly improved their multitasking performance index at the end of the training period. The levels they achieved were superior to the levels achieved by a group of untrained 20-year-olds. When the seniors who completed the multitask training were tested 6 months later, the gains were still present. Hence, The results highlight the potential of the aging brain to improve certain skills. (Torgan C, 2013)

Unfortunately, there are no as such researches available in India where the multitasking ability is being tested in older adults. Hence, an attempt was made to first develop a multitasking paradigm which can be used as a part of neuropsychological rehabilitation for older adults thereby helping them survive with the fast pacing technological world.

In the present study it was planned to develop a multitasking paradigm which is of auditory, visual and motor modality. Since studies suggest that Working memory (WM) abilities are diminished in older adults relative to performance of younger adults (Craik F, TA S, 2000) Aspects of age-related decline in higher cognitive functions such as WM may be related to deficits in perception (Schneider B, Pichora-Fuller M, 2000; Wigfield R.et.al, 1994) although impairment has been shown to exist independent of perceptual differences (TP Zanto.et.al, 2010). Hence, it was aimed at developing a multitasking paradigm which focus on the working memory of the elderly which also has direct consequences on their perceptual abilities, acoustic abilities and attentional span. As evident from table 1 & 2, the patient group took 6 $\pm$ 4.4 minutes to complete the paradigm as compared to control group who took 4.69 $\pm$ 2.32 minutes which shows that there is only the difference of 2 points deviation in the performance of the patient group. As researches suggests plasticity exists in persons with MCI and that its presence is associated with less marked cognitive decline. (Calero MD & Navarro E. 2004) And if multitasking exercises are given timely, it improves the attention and working memory and preserve the quality of life. (Jessica Chia, 2013) Hence from the above results it can be interpreted that such paradigm could prove to be an efficient retraining multitasking module

from cognitive plasticity per se in older adults with mild cognitive impairment, thereby delaying the progression of cognitive decline.

Also, total time taken to recall the correct response by the patient group is less as compared to the control group (127.76±45.3 Vs 132.53 ± 107.72) which is indicating of better performance in multitasking ability by the patient. Though the factors contributing to such improved performance need to be further investigated. It could be due to chance factors such as environmental factors, experimenter's characteristics or could be due to scope of cognitive plasticity in MCI patients. (Calero MD & Navarro E. 2004) Hence, making generalization at this stage is would be critical.

Overall, the main aim of this study was to develop and standardize the multitasking paradigm on older Indian population and develop its norms which can be used to establish where an individual's score lies on a standard scale, by comparing that score with that of other people. (Eatwell, J.1997) Or in other words, to know a person level of functioning at baseline level so that later on quantification can be done for future performances. Such type of study is one of its kinds in Indian medical research set up. Though We hypothesize that multitasking paradigm are successful in improving the executive functioning. Therefore, It is critical to investigate the factors that facilitate generalization of training-induced benefits, so as to improve the efficacy of such programs targeting cognitive decline in older populations.

FUTURE DIRECTIONS

This is new innovative field in the health sector from tertiary rehabilitation per se for Indian population. Hence, to prove its efficacy an intensive study is being done where this paradigm is being used with pre-post design for retraining the multitasking ability in older adults with Mild Cognitive Impairment and early Alzheimer Disease and to better understand the neural basis of such multitasking ability, a neuro-imaging (fMRI) confirmation is also undertaken.

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