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TASK NOVELTY IN VR

THE EFFECTS OF TASK NOVELTY ON MEMORY FOR EVERYDAY MEAL
PREPARATION TASKS AMONG YOUNG ADULTS AND OLDER ADULTS

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science in Clinical Psychology

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Abstract

THE EFFECTS OF TASK NOVELTY ON MEMORY FOR EVERYDAY MEAL
PREPARATION TASKS AMONG YOUNG ADULTS AND OLDER ADULTS

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The use of nonsensical information in the study of learning and memory goes back to the beginning of the field of psychology. Nonsensical information makes it difficult to rely on previous learning, increasing task novelty and providing insight into the learning of new tasks. However, little research exists investigating the role of task novelty in everyday activities such as cooking, which involve overlearned skills. This study aims to investigate the role of task novelty in everyday memory for meal preparation tasks in virtual reality. Young adults ($n = 41$; age $M = 18.77$, $SD = 1.40$) and older adults ($n = 40$; age $M = 74.35$, $SD = 6.44$) and older adults with impaired cognition ($n = 12$; age $M = 66.75$, $SD = 12.72$) completed the Virtual Kitchen Protocol (VKP; Barnett et al., 2021), a virtual reality-based measure of learning and memory for cooking both familiar (e.g., cooking eggs and bacon) and nonsensical (e.g., making flowerpot juice) meals. Young adults had greater recall for both familiar and nonsensical meals than older adults. Among older adults, impaired cognition was associated with lower performance on the sensical meals, but older adults with normal cognition and impaired cognition did not differ in their ability to perform the nonsensical tasks. These results were consistent with the notion that familiarity may be of greater use than novelty. Novelty's impact appears to impact impaired and normal cognition older adults more the young adults.

Keywords: novelty, familiarity, virtual reality, memory for everyday tasks

The Effects of Task Novelty on Memory for Everyday Meal Preparation Tasks Among Young Adults and Older Adults

As far back as Ebbinghaus (1885), psychologists have used nonsensical information to study memory. Nonsensical information controls for prior knowledge and existing associations and provides insight into the learning of novel tasks. The novelty/encoding hypothesis contends that novel information enhances encoding and thus benefits memory, specifically recognition (Reichardt et al., 2020); however, this hypothesis has received inconsistent support in the literature. While nonsensical information has been primarily used to study verbal learning, little research has examined the effects of nonsensical information on procedural memory for everyday tasks. The purpose of this study was to investigate the effects of task novelty on learning and memory for everyday procedural tasks among young adults and older adults.

The Effects of Task Novelty

In the context of memory, novelty refers to any aspect of a target percept that is not already contained in an individual's memory system (Reichardt et al., 2020). Novelty can aid or hamper memory, and novel stimuli may lend themselves to greater encoding and retrieval (Waris et al., 2021). According to the novelty/encoding hypothesis, these novel experiences create new representations, which are more easily recalled or reactivated in the future, contributing to an increase in recognition (Tulving & Kroll, 1995; Reichardt et al., 2020). Research has shown significantly higher recognition rates in novel words in comparison to familiar words and higher false alarms in familiar words (Tulving & Kroll, 1995).

However, the novelty/encoding hypothesis has not carried the field entirely as other lines of research have indicated that a clear association exists between novelty manipulations and physiological markers, including dopaminergic modulation of long-term potentiation in the

hippocampus (Lisman & Grace, 2005). Comparable results have been found in animal models investigating the novelty/encoding hypothesis; however, these results have not been consistently replicable in humans (Shohamy & Adcock, 2010). Other interpretations of results indicate that the rate of false alarms for familiar words was relatively higher than that for novel words, and investigators highlight that interference may be involved in the disparity in novel versus familiar encoding (Dobbins et al., 1998). Several more recent reviews conclude that the novelty/encoding hypothesis is not completely supported by empirical evidence leading to renewed efforts at novelty categorization (Schomaker & Meeter, 2015).

Initial investigations into novelty were focused on a temporal explanation, examining the resilience of memory in the short and long term when presented novel stimuli. However, the temporal aspect of novelty is often excluded from experimental studies as most aim to create complete novelty (Barto et al., 2013). The quantity of novelty has been proposed as a critical aspect of novel stimuli, and thus modern experiments regarding novelty seek to display new stimuli or experiences (Schomaker & Meeter, 2015). The later investigation focused on the unexpected nature of stimuli or events, and tasks usually involve oddball stimuli. While others concentrate on novel arrangements of known stimuli playing on the associative nature of memory to create novelty (Reisenzin et al., 2019). Another area of exploration was spatial novelty, which several researchers have contended has a robust impact on memory. Spatial novelty refers to novel environments and often uses more complex stimuli and is associated with virtual reality in human studies (Schomaker et al., 2014).

Further investigations regarding the effects of novelty on memory recall have been mixed. The *novelty effect* shows greater recognition memory in novel items than old (Tulving and Kroll, 1995; Kormi-Nouri et al., 2005) while the Von Restorff effect consists of better

memory of visual different presented stimuli (Von Restorff, 1933; Kishiyama et al., 2004). These effects on memory have been shown in both short and long-time scales though the suggested mechanism have little to do with novelty. FMRI studies have shown novelty activates both the SN/VTA and hippocampus, brain regions associated with memory and recall; however, participants displayed no enhanced recall (Fenker et al., 2008). Research suggests that time is a factor in novelty-induced memory enhancements improved recall after exploration of novel virtual environments have been shown up to 15 minutes after exposure and have been linked to enhanced learning (Schomaker et al., 2014; Fenker et al., 2008). However, attempts to reproduce these effects have failed (Lisman & Grace, 2005; Roggenhofer et al., 2010; Schomaker et al., 2014).

Much of the research regarding visual tasks pinpoints familiarity as an essential aspect of performance on complex cognitive tasks and minimizes these tasks' cognitive demands (Shen et al., 2020). Findings have shown that familiarity affects not only the retrieval stage of these processes but also the processing activities associated with the later stage completion of complex cognitive tasks (Shen et al., 2020). Effectively, stimulus familiarity can be seen as a stand-in for prior long-term memory and leads to improved speed and quantity of short-term memory consolidation (Xie & Zhang, 2021). Current research has moved toward investigating the impact of familiarity on visual stimuli-based memory tasks and will likely move into the more complex real-world and artificial environment of virtual reality (Smith, 2019).

Memory for Everyday Activities

Memory for everyday tasks is an integral part of functioning (Tulving, 2001) and everyday life (Xie & Zhang, 2021); however, psychologists have understudied it. Age is often associated with declines in daily functions such as medication management, handling of

finances, and meal preparation (Tucker-Drob, 2012). While research has shown associations between neurocognitive decline and age, doubt remains about how appreciable those consequences are for everyday functioning (Willis et al., 2011). In fact, much of the research suggests that older adults function well, and the cognitive declines associated with aging do not display the negative impacts that many would expect to see on daily behaviors (Tucker-Drob, 2012). This disconnect gives birth to the school of thought that everyday functioning is unrelated to neurocognitive aging and may rely on knowledge and personality factors. First, while the efficiency of cognitive processing may decline with age, the opposite is true with knowledge stores, and personality being relatively stable throughout an individual's lifespan (Tucker-Drob & Salthouse, 2008). Second, the possibility that neurocognitive functions are essential for the acquisition of the ability to perform these everyday tasks, they essentially run-on autopilot after they are acquired and as such are causally independent of neurocognitive function (Salthouse, 2010). Daily tasks depend on cognitive processing; however, the amount needed to complete these tasks is so minimal that only severe cognitive deficits affect them (Tucker-Drob, 2012).

Mild cognitive impairment (MCI) has been conceptualized as an intermediate state of age-related cognitive decline and mild dementia (Peterson et al., 1999). Whereas basic activities (e.g., bathing, getting dressed) remain intact for those with MCI complex activities (e.g., cooking and shopping) decline below previous levels especial those dependent on memory, attention, and other higher order cognitive abilities (Pernecky et al., 2006). Studies consistently show poorer performance amongst cognitively impaired groups as compared to the nonimpaired counterparts and have been shown to be predictive of later development of Alzheimer's disease (Tabert et al., 2002). Furthermore, consistent findings have shown individuals with MCI have limitations in various everyday tasks due to memory impairment, specifically those requiring episodic memory

(Kazui et al., 2005).

Using Virtual Reality to Study Everyday Memory Functioning

Cognition and its subprocesses like memory have been argued to be a dynamic system, and a variety of things impact the measurement and generalizability outside of the testing room. This has led many researchers to conclude that there is a need for neuropsychological tests with greater ecological validity (Waris et al., 2021). Virtual reality offers the opportunity to obtain a standardized measurement of abilities in an immersive, lifelike environment (Smith, 2019). The synthesis of virtual reality testing in traditional neuropsychological assessments allows for the increase in the verisimilitude and veridicality of the tasks and unlocks potentially unlimited situations to apply to testing (Smith, 2019; Parsons, 2011).

There is a growing body of research on the use of virtual reality-based assessments to measure better real-world cognitive abilities, which removes one of the significant constraints of the laboratory and office settings (Kim et al., 2019). Virtual reality allows for testing multiple domains of everyday tasks such as driving, shopping, or even cooking. A significant benefit of virtual reality assessments in the clinical population is that the environments are controlled, allowing for distractions and interruptions for testing high order function in the office's safety and may help test for impairments known to characterize specific disorders (Parsey & Schmitter-Edgecombe, 2013). However, one challenge to virtual reality-based tests of everyday functioning is the need to control task novelty and how to measure its impacts on performance empirically. For example, on a meal preparation task, individuals may have various levels of experience with meal preparation, and some may know how to cook some dishes but not others (Barnett et al., 2021). Yet, daily life often involves novel challenges and a need to adapt to different circumstances, even when doing routine and repetitive activities.

The Current Study

This study aims to investigate the role of task novelty in everyday memory for meal preparation tasks in virtual reality among young adults, older adults with normal cognition, and older adults with impaired cognition. Although it is possible that task novelty could enhance encoding or aid retrieval, overall, we expected task novelty to have a negative effect on recall of meal preparation tasks because it limits the beneficial effects of task familiarity. Thus, the use of novel/nonsensical cooking tasks may control for experience in real-world cooking since it limits the amount of transferrable skills an individual can bring to bear. While most people are familiar with how to prepare a familiar meal such as bacon and eggs, participants are unlikely to have prior experience putting a flowerpot in to a blender and turning it into a smoothie. We hypothesized (H_1) that participants would have lower recall of nonsensical cooking tasks, reflecting the notion that individuals do not have learned routines. We hypothesized (H_2) that task novelty would impact older adults more than young adults, reflecting older adults' reliance on learned routines and diminished capacity to adapt to novel applications of these routines. Lastly, we hypothesized (H_3) that the impaired cognition group would have the poorest performance, reflecting the typical struggles with complex everyday tasks, their reliance on learned routines, and a diminished capacity to adapt those routines.

Methods

Participants

This study used archival data from two studies: Using Virtual Reality Environments to Assess Neuropsychological Functioning and Virtual Reality-Based Assessment of Function Capacities in Individuals with Alzheimer's Disease and Alzheimer's Disease Related Dementia. Both studies were approved by the University of Texas at Tyler committee for the protection of

human subjects, and informed consent was obtained from all participants. For this study, participants were excluded from analyses if the individual fell outside of the age range or if the case contained missing data. It should also be noted that, in the aforementioned studies, individuals were not administered the virtual reality component if they have a pacemaker or defibrillator, hearing aids, epilepsy, or a history of seizures. The participants were split into 3 groups by age and cognitive impairment using a MMSE-2 score of 24 or below to mark impaired cognition.

Measures

Familiar and Nonsensical Meal Preparation Tasks. The Virtual Kitchen Protocol: Learning and Memory (VKP: LM; Barnett et al., 2021) is a virtual reality-based task measuring memory and adaptive functioning for meal preparation. The VKP is a protocol that utilizes the Job Simulator virtual reality game (Copyright © 2021 Owlchemy Labs). The VKP: LM involves making 18 meals of various complexity in a virtual reality environment (Appendix A). Initially participants go through a tutorial introducing them to the virtual environment and the control scheme for the task. Next, the participants go through a teaching trial in which they orient themselves to the meals and preparation techniques required for completing them. The teaching trial consist of 6 meals; 3 of which resemble normal everyday recipes and 3 which are nonsense or nonsensical instructions (e.g., toasted menu and tea). The research assistants guided participants to complete the teaching trial. Immediately following the teaching trial, the participants go through a short-delay recall trial and make all six meals with researcher assistance. After an additional 20 minutes, a long delay recall trial is administered once again without researcher assistance. The task concludes with a force recognition task in which the participants answer yes/no questions regarding the task they have completed. For the purposes of

data analysis, the VKP: LM score was broken up into four variables separating the task scores first by immediate or delayed recall and then once more in nonsensical or familiar meal. Scores for these variables were calculated by the correctness of the meals based on the introductory teaching trial instruction.

Analytic Plan

Data was analyzed using SPSS version 28. The young adult group consisted of individuals aged 18-25. Older adults were individuals aged 65-90. This group was further divided into those with normal cognition (MMSE-2 score ≥ 25) or impaired cognition (MMSE-2 score ≤ 24). Age cognition group was coded as a discrete variable in which young adults [YA], older adults with normal cognition [NC], and older adult with impaired cognition [IC] was coded 0, 1, and 2, respectively. Correlational and descriptive data was initially assessed to determine if a relationship existed between age, cognition, premorbid IQ, computer comfort, and VKP scores. Four independent-samples Kruskal-Wallis tests were used to investigate group differences on cooking tasks, scores across nonsensical and familiar meals in both the immediate delayed recall. Mann-Whitney U test were run to examine group differences across tests.

Results

Participant characteristics of the overall study are displayed in Table 1. Bivariate correlations between all study variables are displayed in Table 2. We found significant negative correlations between performance on the nonsensical meal tasks and real-world cooking comfort.

For the MANCOVA, the assumptions of normality and homogeneity of variance was not met even after attempting to transform the variables. Thus, we used the non-parametric Kruskal-Wallis test followed by a post hoc Mann-Whitney analysis scheme. A significant difference was found between the three groups' performance on the immediate delay nonsensical cooking task score, $\chi^2(2, N = 82) = 44.71, p < .001, \epsilon^2 = 0.55$. A post-hoc test using Dunn's test with

Bonferroni correction showed the significant difference between young adults and normal cognition older adults, $p < 0.001$, and between young adults and impaired cognition older adults, $p < 0.001$. However, no significant difference was found between the normal cognition older adults and impaired cognition older adults.

The three groups also had a significant difference in performance on the immediate delay familiar cooking task score, $\chi^2 (df = 2, N = 82) = 34.67, p < 0.001, \epsilon^2 = .43$. A post-hoc Dunn's test with Bonferroni correction found a significant difference between young adults and normal cognition older adults, $p < 0.001$, young adults and impaired cognition older adults, $p < 0.001$, and normal cognition older adults and impaired cognition older adults, $p = 0.01$.

Two groups also had a significant difference in performance on the delayed recall nonsensical cooking task score, $\chi^2 (df = 2, N=82) = 47.92, p < 0.001, \epsilon^2 = .59$. A post-hoc Dunn's test with Bonferroni correction found the significant difference between young adult and normal cognition older adult, $p < 0.001$, young adult and impaired cognition older adults, $p < 0.001$. However no significant difference was found between the normal cognition older adults and impaired cognition older adults.

The three groups also had a significant difference in performance on the delay recall familiar cooking task score, $\chi^2 (df = 2, N=82) = 38.57, p < .001, \epsilon^2 = .48$. A post-hoc test using Dunn's test with Bonferroni correction show the significant difference between young adults and normal cognition older adults, $p < 0.001$, young adults and impaired cognition older adults, $p < 0.001$, and normal cognition older adults and impaired cognition older adults, $p = 0.01$.

Discussion

The purpose of this study was to investigate differences in completing novel and familiar meals in a virtual cooking task among young adults, older adults with normal cognition, and

older adults with impaired cognition. Among all three groups, performance on familiar meals was greater than that on nonsensical meals. This result supports our hypothesis (H_1) that familiar meals would be more easily recalled than nonsensical meals. Also, the poorer performance of the older adult on recalling nonsensical meals supports our hypothesis (H_2) that novelty would have a greater impact on older adults, reflecting their overreliance on learned routine. While the impaired cognition group performed the poorest, the difference between that group and the normal cognition group was not significant. However, the limited sample size and nearly significant results suggest that our third hypothesis may also be supported with a larger sample. In addition, while the delay scores for nonsensical meals remained lower than those of the normal meals, both means were slightly higher in both the young adults and normal cognition older adult samples. The impaired cognition group, however, showed only declines in the nonsensical meals. This supports the idea that individuals of advanced age and impaired cognition would be more significantly impacted by novel/nonsensical tasks, indicating a potential overreliance on learned routines and a lack of cognitive flexibility to adapt to new and strange applications of this routine.

At odds with prior literature, everyday tasks seem susceptible to cognitive decline performance across tasks decrease as age and cognitive impairments increased (Pernecky et al., 2006). This suggests that more significant cognitive impairment may not be necessary for there to be an impact in individuals' ability to perform everyday tasks. Lower scores by increased age indicate the slower consolidation of novel information and a more limited ability to link this added information with existing related routines (Xie & Zhang, 2021). In this case, the novel/encoding hypothesis seems to fall short of explaining the phenomena relating to the use of novel information in daily tasks, as while individuals remembered nonsensical orders to a similar

degree after the delay as the normal orders, no real advantage was displayed over the sensical meal orders (Shohamy & Adcock, 2010). Additionally, among the older adults with impaired cognition, the novelty seems to have been slightly better for the delay scores, however the scores were below the other groups by a large amount indicating that limited capacity for adaptation may play a larger role in the impact of novel and familiar information in completing daily tasks (Salthouse, 2010).

Novelty has long served as a wrinkle in psychological experimentation, with mixed interpretations of its role in the encoding of memory (Tulving & Kroll, 1995; Reichardt et al., 2020). Our findings provide some evidence against the novelty/encoding hypothesis in that retrieval of both familiar and nonsensical meals remained intact across the young and older adult groups. However, nonsense meal scores decline as cognition decline, suggesting that novelty or at least spatial novelty and contextual novelty (Reisenzin et al., 2019). Indicating that novelty is perhaps more complex than initially thought and that the mixing of novelty categorizations that occur in virtual reality may produce a stacking effect requiring more cognitive capacity leading to issues with older and cognitively impaired individuals encoding information as well as their younger counterparts (Reisenzin et al., 2019).

Regarding the use of and need for virtual reality for gaining greater ecological validity of neuropsychological assessment, our study does not provide evidence for or against the creation of virtual reality tasks for creating a more thorough understanding of individuals real world capabilities (Waris et al., 2021). The VKP seems to be a helpful introduction to novel techniques for real-world tasks. The nonsensical meals appear to pose sufficient control for learned behaviors as nonsensical scores across groups decreased in groups with greater real-world cooking experience. This suggests that the VKP may be a good approximation of in-vivo

adaptation ability in individuals (Barnett et al., 2021). The ability to safely complete nonsensical requests allows for the introduction of controls. However, familiarity seems strongly tied to performance on the task, in line with research into visual tasks, which highlights it as an essential part of the performance on complex cognitive tasks (Shen et al., 2020).

Limitations of the current study include the small number of participants with significantly impaired cognition. The use of the MMSE-2 to group cognition levels also limits the study due to the imprecise nature of the measure. The lack of a more comprehensive questioning of the cooking and computer abilities of the participant makes comparisons and covariates challenging to quantify. The limited sample size does not allow for more complex interaction-focused statistical analysis leaving questions regarding moderating or mediating variables in the age cognition group relationship with VKP scores.

The conclusions drawn from the current study are that nonsensical information may be an effective way to control for previously-learned behaviors. Secondly, in support of previous research, everyday tasks are robust to age-related declines, and more significant cognitive impairments are required to impact this procedural memory system (Salthouse, 2010). Additionally, familiarity is an essential part of the visual task-related processing and consolidation, questioning the novel/encoding hypothesis in investigating more complex novelty types (Shohamy & Adcock, 2010). Lastly, the use of virtual reality in neuropsychological testing allows for a greater understanding of the impacts of age and cognition on real-world tasks.

Further research should include all ages and cognitive levels when feasible. Including more meal order sets may also provide a further understanding of the VR world and allow those with lower cognition or tech-savvy to adapt to the controls and environment, possibly allowing for greater approximation of real-world skills (Waris et al., 2021). Including the recognition trial

would be a good check that the participants understood the task. Virtual reality should continue to be investigated as a way for clinicians and researchers to see the real-world ability of individuals and perhaps work to create a more concrete normalization of this task to extend their use in the clinical population (Parsey & Schmitter-Edgecombe, 2013).

Overall, this study explored the role of task novelty in everyday memory for meal preparation tasks in virtual reality. Our findings suggest that novelty results in decreased scores across age cognition groups. Also, impaired older adult displayed decreases from the immediate recall to delay recall tasks in the cognitively impaired older adults contrary to the increases in the other groups. These findings support previous research into the robust nature of memory for everyday tasks and highlight the need for a broader investigation into novelty, virtual reality, and cognition.

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Tables

Table 1: *Participant Characteristics*

Variable	Total sample <i>n</i> = 82
Age (years)	47.52 (27.9)
Sex (female)	59.8%
Race	
<i>White</i>	90.2%
<i>Black</i>	1.2%
<i>Asian</i>	2.4%
<i>Other</i>	1.2%
Hispanic/Latino/a	7.3%
Marital status	
Education(other)	29.3%
VKP	
Immediate recall nonsense	20.0 (9.5)
Immediate recall regular	26.0 (9.7)
Delayed recall nonsense	20.8 (8.9)
Delayed recall regular	27.9 (8.7)
Computer competency	3.6 (1.0)
Cooking comfort	4.7 (4.4)
Cooking frequency	3.9 (6.3)
VKP comfort*	4.2 (1.2)

* How comfortable are you with the virtual kitchen?

Table 2: *Bivariate Correlations Between All Study Variables.*

	1	2	3	4	5	6	7
1. Immediate Recall Nonsense							
2. Immediate Recall Regular	.81**						
3. Delayed Recall Nonsense	.89**	.79**					
4. Delayed Recall Regular	.78**	.89**	.82**				
5. Computer competency ¹	.37*	.38**	.40**	.38**			
6. Cooking comfort ²	-.11	-.22*	-.11	-.28**	-.13		
7. Cooking frequency ³	.15	-.24*	-.11	-.30**	-.14	.98**	
8. VKP comfort ⁴	.17	.10	.13	-.01	.08	.66**	.62**

*Correlation is significant at .05

**correlation is significant at .01

1. How would you rate your computer competency in terms of know how to use a computer?
2. How comfortable are you cooking meals (something made with more than a microwave) in a real kitchen?
3. How often do you prepare cooked meals (again something made with more than a microwave) in a real kitchen?
4. How comfortable are you with the virtual kitchen?

Table 3: Means, standard deviations, and Kruskal Wallis of VKP by study group

Measure	Young adults		Normal cognition older adult		Cognitively impaired older adults		$X^2 (2,82)$	η^2
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Immediate Recall Nonsense	26.77	4.66	16.42	6.93	5.40	8.25	44.71*	.55
Immediate recall regular	31.51	3.41	25.03	7.63	7.63	9.12	34.67*	.43
Delayed recall nonsense	27.38	4.27	17.33	6.05	6.40	7.17	47.92*	.59
Delayed recall regular	32.82	2.48	27.51	5.93	10.10	9.20	38.54*	.48

* $p < .001$

Table 4: *Mean rank differences and Mann-Whitney Us by study group*

Measure		Mean rank difference	Z	SD	$P_{\text{bonf.}}$
Immediate Recall nonsense	NC – IC	18.74	2.18	8.58	.09
	YA – NC	47.64	5.65	8.43	<.01
	YA – IC	28.89	5.13	5.63	<.01
Immediate recall regular	NC – IC	24.50	2.86	8.57	.01
	YA – NC	45.82	5.45	8.41	<.01
	YA – IC	21.32	3.80	5.61	<.01
Delayed recall nonsense	NC – IC	19.39	2.26	8.59	.07
	YA – NC	49.30	5.85	8.43	<.01
	YA – IC	29.92	5.32	5.63	<.01
Delayed recall regular	NC – YA	25.49	2.99	8.54	.01
	YA – NC	48.02	5.73	8.38	<.01
	YA – IC	25.53	4.03	5.59	<.01

Young adults [YA], normal cognition older adults [NC], impaired cognition older adults [IC]

Appendix A

Virtual Kitchen Protocol and Scoring

Job Simulator Protocol Instructions

Key

- Scoring: Incorrect/No = 0; Correct/Yes = 1
- Italicized text is text meant to be read to the participant.
- Bold text is meant for you to circle the participant's response.

Handling Simulator Sickness: If participants express any discomfort (e.g., dizziness, nausea), ask them: "Are you OK?" and "Are you able to continue?" If the participant says no to either question (or if they say yes to both but express or show signs of discomfort), immediately discontinue the VR tasks. Allow them water and a short break and administer traditional tests. You can ask them later in the day (e.g., after lunch) if they are comfortable trying the virtual reality program again.

Fall Prevention: Be careful of any wires or other objects that may represent a tripping hazard. Put the HMD (head mounted display) on the participant when they are sitting down, and the participant is to remain sitting down at all times while wearing the HMD. If the participant attempts to stand, instruct them to remain seated during the procedure. Even once the HMD is removed, offer the participant a hand in standing up in case they are dizzy, even if they have not expressed any simulator sickness. In short, assume that the participant might be at risk to fall at all times.

How to get into Job Simulator: Open Steam. Make sure that the VR headset is plugged into the computer. Click on the "VR" displayed in the right-hand corner of steam tab-bar at the top of the window. Make sure both cameras, both handsets and the headset are registering. Start Job Simulator. Once JS loads, set the window to full screen and then click outside of the window by moving the mouse outside of the visible area on the screen. At this point, the person with the headset should be able to see the VR loading kiosk. Make sure the laptop's volume is set to "dual." Make sure the VR audio is set to "HDMI." Sound should be playing through the headset at this point. From the headset, open the lower door labeled "Options" on the kiosk and pull the yellow lever up so that it is "on." Then move the knob on the front of the kiosk from the left side all the way to the right. The screen above the knob should now say "Free play mode." Then pull the lever to the right of kiosk to start JS.

TUTORIAL

Before we get started, how comfortable are you cooking meals (something made with more than a microwave) in a real kitchen? Please answer on a scale of 1 to 5, 1 being not at all comfortable and 5 being very comfortable.

How often do you prepare cooked meals (again, something made with more than a microwave) in a real kitchen? Please answer on a scale of 1 to 5, 1 being never and 5 being very frequently.

Today you are going to be working out of a virtual kitchen to make a few meals. But first we are going to take some time to familiarize you with your surroundings and the controls. First, I will teach you how to pick up and move objects. Turn to your left until you see a small fruit tree to the left of the sink. Position your wand over a piece of fruit and press your index finger on the trigger button to grab a fruit. While holding the trigger, move your hand. Bring the fruit over to the counter and release the trigger button to release the fruit.

If no, say: That's OK. Let's try again. Position your controller so that your hand is over a piece of fruit. The fruit should turn blue. While your hand is still on it, press and hold the trigger before moving it to the counter.

If participant continues to struggle, ask permission to guide them: Here, maybe I can help. Would it be alright for me to grab your hand to show you the button? OK, I'm going to move your pointer finger over the trigger now.

Good. Now I want you to throw the fruit out of the smaller window to your right. To do this first pick up the fruit using the trigger, and then throw the fruit by releasing the trigger mid-swing while moving your arm towards the window.

If no, say: That's OK. Let's try again. Position your hand over the fruit and the fruit should turn blue. Then press the trigger to pick it up. Then swing the hand holding the fruit towards the window and release the trigger while you're still swinging your hand towards the window.

Good. Now turn left to find the fridge. Pull the lever to the right of the fridge to change it to the pantry by pressing and holding the trigger and moving your controller down. Good. Open and close the pantry in the same way you just pulled the lever: grab the handles by pressing the trigger and moving your hand.

If no, say: That's OK. Let's try again. Position your controller so that your hand is over the pantry door handle. While your hand is still on the door handle, press and hold the trigger before moving it toward yourself.

Good. Now turn to face the larger window. In front of you are two cooking stations. The one on your left is currently a sink. It also includes a toaster, a blender, and a sandwich maker. For different meals, you will need to use different appliances. Switch the left cooking station to the blender by moving your controller over to the dial under the sink, and then press and hold the trigger while tilting your controller to move the dial to the blender setting. Good. Now you know everything you need to make food in the virtual kitchen.

Before we move on, I need to ask you a quick question. How comfortable are you with the virtual kitchen? Please answer on a scale of 1 to 5, 1 being not at all comfortable and 5 being very comfortable.

MEMORY SECTION

We are going to make some orders together – some will be normal food orders and others will make no sense. We will teach you how to do each of them.

TEACHING TRIAL

Order 1 (normal, easy, toast and tea)

One order you need to make is toast and tea with lemon. Turn to your left to see the blender. Move the dial under it to change the blender to the toaster. Find a piece of bread from the counter and hold the trigger to grab it. Place the bread in the toaster and then pull the lever to start the toaster. When it pops up, place it on the plate. Now for the tea. Open the pantry and find the tea bags. Move one tea bag to the counter in between the cooking stations. Then change the left cooking station from the toaster to the sink. Look down and to your right to locate the red kettle. Pick up the kettle, place it under the faucet, and turn on the water until the kettle is full. Locate the grill (the cooking station on the right). Place the kettle with water on the grill and rotate the heat dial on the left below the grill to the middle. When the water in the kettle boils, you will hear the kettle whistle. When the kettle whistles, turn off the heat. Grab a mug from the same area you retrieved the kettle, place it on the counter, and drop the tea bag inside the mug. Pour water from the kettle into the mug until it is near the top. Place the mug onto the serving plate with the toast. Grab a lemon from the plant on your left and place it on the plate. Ring the bell to send out this first order.

Order 2 (nonsense, easy, toast a menu)

Another order you will need to make is a toasted menu with soap drink and cherry stem. First change the sink to the toaster. Now locate a menu on the lower shelf under the right window and stick it in the toaster to toast it. When it pops up, throw the toasted menu on top of the fridge. Now switch the toaster back to the sink. Grab the kettle and fill it with soap. Place the kettle on the grill. Boil the soap until it is smoking. Pour the boiling soap into a mug. Find a cherry from the pantry and bring it slowly towards your head in order to bite it. Now place the cherry stem into the mug of hot soap. Next find the flowerpot on the counter between the two windows. Grab just the flower out of the flowerpot and then place it in the mug. Throw the mug out of the window to your right. To signal your completed order, press the fire extinguisher.

Order 3 (normal, hard, eggs and bacon)

Another order you need to fulfill is eggs, with salt and pepper and throwing the shells out the window, and bacon. Remove the kettle from the grill, empty it into the sink, and then place it aside. Switch the lever to the right of the pantry to the fridge setting. Open the fridge and pull out one egg. Crack the egg onto the grill. Be sure that you immediately dispose of your eggshells. In this case, throw them out of the window to your right. Grab the salt and pepper from the shelf behind you and sprinkle it on the items on the grill. Place the grill on medium heat until the egg turns slightly brown around the edges. Remember that things will cook faster in the virtual kitchen than in reality. Turn the heat off and place the egg on the plate. Find two pieces of bacon in the freezer and place them on the grill. Turn the heat up until the bacon browns. Place them on the plate. Ring the bell to serve your order.

Order 4 (nonsense hard, steak, and broccoli)

The next order you need to fulfill is burnt steak (remembering to eat it) and broccoli, making sure to add milk and grape juice. Open the fridge and pull out two stalks of broccoli. Place them on the grill. Then go to the freezer and pull out one piece of steak. Place that on the grill as well. Go to the fridge and find milk. Pour it on the items on the grill. Throw the milk carton out of the window. Then switch the fridge to the pantry. Find the grape juice, uncork it, and pour the grape juice on the items on the grill. Place the grill on high heat until everything is black and burnt. Turn the heat off. Grab the steak and bring it slowly towards your head until you eat it down to the bone. Throw the steak bone out of the right window. To signal that this order is complete, press the fire extinguisher.

Order 5 (normal, easy, orange juice)

Another order you need to fulfill is orange juice. First switch the sink to the blender. Find an orange from the plant on the left and place it in the blender. Pull the knob on the left side of the blender to blend the orange into orange juice. Find a cup from the shelf on your right and place it under the blender spout. Push the dispenser to pour orange juice into the cup. Place the cup on the plate and ring the bell to serve this order.

Order 6 (nonsense, easy, flowerpot juice)

Another order you need to fulfill is flowerpot juice. For this order, find the flowerpot on the counter on your right and place it in the blender. Pull the knob to blend it into flowerpot juice. Find a cup from the shelf on your right and place it under the blender spout. Push the dispenser to pour flowerpot juice into the cup. Take the cup, throw it out of the right window. Then press the fire extinguisher to signal that you have completed the order.

IMMEDIATE RECALL TRIAL

Please listen carefully because I can only read this once. Not everyone will remember everything, so just try your best. Please wait for me to finish reading before you begin. Now, I want you to do everything you just did. I will list it out for you now, ready? You will make the following orders [pause briefly between each order]: toast and tea with lemon – toasted menu with soap drink and cherry stem – eggs with salt and pepper (making sure to throw the shells out the window) and bacon – burnt steak (remember to eat it) and broccoli (making sure to add milk and grape juice) – orange juice – and flowerpot juice.

When the participant is finished: Please allow me to remove the headset. We are going to do some different tasks for a few minutes.

DELAYED RECALL TRIAL

Okay, let's put the headset back on, and get back to the virtual kitchen for your next task. Please listen carefully. Wait for me to finish reading before you begin. Now, I want you to try to recall everything you did in the virtual kitchen earlier today. Please do as much as you can remember. If you remember something later, please go back and do it. Not everyone will remember everything, so just try your best. I will not be able to help you. Please go as quickly as you can. You may begin.

FORCED-CHOICE RECOGNITION

Okay. Let's remove the headset so I can ask you some questions. I am going to ask you to recall some things you did in the virtual kitchen. Each question I ask you will have two options to choose from. Please respond with the option you think is correct.

Job Simulator Scoring Protocol

Screening Suitability

Do you have a cardiac pacemaker? Y* N

Do you wear hearing aids? Y* N

Do you have defibrillators in your body? Y* N

Do you have epilepsy? Y* N

Do you have a history of seizures? Y* N

*If the participant answers "yes" to any of these items, do not administer the Job Simulator Protocol.

Scale Rating Questions

How comfortable are you cooking meals (something made with more than a microwave) in a real kitchen? Please answer on a scale of 1 to 5, 1 being not at all comfortable and 5 being very comfortable. 1 2 3 4 5

How often do you prepare cooked meals (again, something made with more than a microwave) in a real kitchen? Please answer on a scale of 1 to 5, 1 being never and 5 being very frequently. 1 2 3 4 5

How comfortable are you with the virtual kitchen? Please answer on a scale of 1 to 5, 1 being not at all comfortable and 5 being very comfortable. 1 2 3 4 5

Teaching Trial Scoring

Order 1 (normal, easy, toast and tea)		Order 2 (nonsense, easy, toasted menu)	
Did they put anything in the toaster?	0 1	Did they put anything in the toaster?	0 1
Was it bread?	0 1	Was it the menu (or if needed, a book)?	0 1
Did they pull the lever on the toaster?	0 1	Did they pull the lever on the toaster?	0 1
Did they put what they toasted on a plate?	0 1	Did they throw what they toasted on the fridge?	0 1
Did they pour any liquid into the kettle?	0 1	Did they pour any liquid into the kettle?	0 1
Was it water?	0 1	Was it soap?	0 1
Did they boil something?	0 1	Did they boil something?	0 1
Did they put what they boiled in a mug?	0 1	Did they put what they boiled in a mug?	0 1
Did they put anything solid in the mug?	0 1	Did they put anything solid in the mug?	0 1
Was it a teabag?	0 1	Was it a cherry stem?	0 1
Did they put a lemon on the plate?	0 1	Did they put a flower in the mug?	0 1
Did they put the mug on the plate?	0 1	Did they throw the mug out of the window?	0 1
Did they ring the bell?	0 1	Did they hit the fire extinguisher?	0 1
Subtotal		Subtotal	
Order 3 (normal, hard, eggs and bacon)		Order 4 (nonsense, hard, steak and broccoli)	
Did they put two different food items on the grill?	0 1	Did they put two different food items on the grill?	0 1
Was one of the items an egg?	0 1	Was one of the items broccoli?	0 1
Was it precisely one egg?	0 1	Was it precisely two stalks of broccoli?	0 1
Did they crack the egg?	0 1	Was one of the items steak?	0 1
Did they throw out the shells?	0 1	Was it precisely one steak?	0 1
Did they add salt?	0 1	Did they eat the steak?	0 1
Did they add pepper?	0 1	Did they add milk?	0 1
Was one of the items bacon?	0 1	Did they throw the milk carton out of the window?	0 1
Was it precisely two pieces of bacon?	0 1	Did they pour grape juice on the items on the grill?	0 1
Did they turn on the grill?	0 1	Did they turn on the grill?	0 1
Did they not burn anything?	0 1	Did they burn anything?	0 1
Did they put what they cooked on the plate?	0 1	Did they throw the steak bone out of the window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Subtotal		Subtotal	
Order 5 (normal, easy, orange juice)		Order 6 (nonsense, easy, flower pot juice)	
Did they put an object in the blender?	0 1	Did they put an object into the blender?	0 1
Was it an orange?	0 1	Was it a flower pot?	0 1
Did they turn on the blender?	0 1	Did they turn on the blender?	0 1
Did they pour the liquid into a cup?	0 1	Did they pour the liquid into a mug?	0 1
Did they put the cup on a plate?	0 1	Did they throw the mug out of the right window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Subtotal		Subtotal	
		Total Correct	

IMMEDIATE RECALL TRIAL

Please listen carefully because I can only read this once. Not everyone will remember everything, so just try your best. Please wait for me to finish reading before you begin. Now, I want you to do everything you just did. I will list it out for you now, ready?

You will make the following orders [pause briefly between each order]: toast and tea with lemon – toasted menu with soap drink and cherry stem – eggs with salt and pepper (making sure to throw the shells out the window) and bacon – burnt steak (remember to eat it) and broccoli (making sure to add milk and grape juice) – orange juice – and flower pot juice.

Immediate Recall Scoring

Order 1 (normal, easy, toast and tea)		Order 2 (nonsense, easy, toasted menu)	
Did they put anything in the toaster?	0 1	Did they put anything in the toaster?	0 1
Was it bread?	0 1	Was it the menu (or if needed, a book)?	0 1
Did they pull the lever on the toaster?	0 1	Did they pull the lever on the toaster?	0 1
Did they put what they toasted on a plate?	0 1	Did they throw what they toasted on the fridge?	0 1
Did they pour any liquid into the kettle?	0 1	Did they pour any liquid into the kettle?	0 1
Was it water?	0 1	Was it soap?	0 1
Did they boil something?	0 1	Did they boil something?	0 1
Did they put what they boiled in a mug?	0 1	Did they put what they boiled in a mug?	0 1
Did they put anything solid in the mug?	0 1	Did they put anything solid in the mug?	0 1
Was it a teabag?	0 1	Was it a cherry stem?	0 1
Did they put a lemon on the plate?	0 1	Did they put a flower in the mug?	0 1
Did they put the mug on the plate?	0 1	Did they throw the mug out of the window?	0 1
Did they ring the bell?	0 1	Did they hit the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
Order 3 (normal, hard, eggs and bacon)		Order 4 (nonsense, hard, steak and broccoli)	
Did they put two different food items on the grill?	0 1	Did they put two different food items on the grill?	0 1
Was one of the items an egg?	0 1	Was one of the items broccoli?	0 1
Was it precisely one egg?	0 1	Was it precisely two stalks of broccoli?	0 1
Did they crack the egg?	0 1	Was one of the items steak?	0 1
Did they throw out the shells?	0 1	Was it precisely one steak?	0 1
Did they add salt?	0 1	Did they eat the steak?	0 1
Did they add pepper?	0 1	Did they add milk?	0 1
Was one of the items bacon?	0 1	Did they throw the milk carton out of the window?	0 1
Was it precisely two pieces of bacon?	0 1	Did they pour grape juice on the items on the grill?	0 1
Did they turn on the grill?	0 1	Did they turn on the grill?	0 1
Did they not burn anything?	0 1	Did they burn anything?	0 1
Did they put what they cooked on the plate?	0 1	Did they throw the steak bone out of the window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
Order 5 (normal, easy, orange juice)		Order 6 (nonsense, easy, flower pot juice)	
Did they put an object in the blender?	0 1	Did they put an object into the blender?	0 1
Was it an orange?	0 1	Was it a flowerpot?	0 1
Did they turn on the blender?	0 1	Did they turn on the blender?	0 1
Did they pour the liquid into a cup?	0 1	Did they pour the liquid into a mug?	0 1
Did they put the cup on a plate?	0 1	Did they throw the mug out of the right window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
		Total Correct	

When the participant is finished: Please allow me to remove the headset. We are going to do some different tasks for a few minutes.

Time at the end of the Immediate Recall Trial: _____

(20-minute delay)

Time to begin the Delayed Recall Trial: _____

DELAYED RECALL TRIAL

Long Delay Recall Scoring

Order 1 (normal, easy, toast and tea)		Order 2 (nonsense, easy, toasted menu)	
Did they put anything in the toaster?	0 1	Did they put anything in the toaster?	0 1
Was it bread?	0 1	Was it the menu (or if needed, a book)?	0 1
Did they pull the lever on the toaster?	0 1	Did they pull the lever on the toaster?	0 1
Did they put what they toasted on a plate?	0 1	Did they throw what they toasted on the fridge?	0 1
Did they pour any liquid into the kettle?	0 1	Did they pour any liquid into the kettle?	0 1
Was it water?	0 1	Was it soap?	0 1
Did they boil something?	0 1	Did they boil something?	0 1
Did they put what they boiled in a mug?	0 1	Did they put what they boiled in a mug?	0 1
Did they put anything solid in the mug?	0 1	Did they put anything solid in the mug?	0 1
Was it a teabag?	0 1	Was it a cherry stem?	0 1
Did they put a lemon on the plate?	0 1	Did they put a flower in the mug?	0 1
Did they put the mug on the plate?	0 1	Did they throw the mug out of the window?	0 1
Did they ring the bell?	0 1	Did they hit the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
Order 3 (normal, hard, eggs and bacon)		Order 4 (nonsense, hard, steak and broccoli)	
Did they put two different food items on the grill?	0 1	Did they put two different food items on the grill?	0 1
Was one of the items an egg?	0 1	Was one of the items broccoli?	0 1
Was it precisely one egg?	0 1	Was it precisely two stalks of broccoli?	0 1
Did they crack the egg?	0 1	Was one of the items steak?	0 1
Did they throw out the shells?	0 1	Was it precisely one steak?	0 1
Did they add salt?	0 1	Did they eat the steak?	0 1
Did they add pepper?	0 1	Did they add milk?	0 1
Was one of the items bacon?	0 1	Did they throw the milk carton out of the window?	0 1
Was it precisely two pieces of bacon?	0 1	Did they pour grape juice on the items on the grill?	0 1
Did they turn on the grill?	0 1	Did they turn on the grill?	0 1
Did they not burn anything?	0 1	Did they burn anything?	0 1
Did they put what they cooked on the plate?	0 1	Did they throw the steak bone out of the window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
Order 5 (normal, easy, orange juice)		Order 6 (nonsense, easy, flower pot juice)	
Did they put an object in the blender?	0 1	Did they put an object into the blender?	0 1
Was it an orange?	0 1	Was it a flower pot?	0 1
Did they turn on the blender?	0 1	Did they turn on the blender?	0 1
Did they pour the liquid into a cup?	0 1	Did they pour the liquid into a mug?	0 1
Did they put the cup on a plate?	0 1	Did they throw the mug out of the right window?	0 1
Did they ring the bell?	0 1	Did they press the fire extinguisher?	0 1
Did they serve this meal as a whole?	0 1	Did they serve this meal as a whole?	0 1
Subtotal		Subtotal	
		Total Correct	

FORCED-CHOICE RECOGNITION

- Did I ask you to throw eggshells or bacon out of the right window? : 0 1
- Did I ask you to cook one stalk or two stalks of broccoli? : 0 1
- Did I ask you to cook one or two eggs? : 0 1
- Did I ask you to put an apple stem or a cherry stem in a mug? : 0 1
- Did I ask you to make tea or a smoothie? : 0 1
- Did I ask you to burn a steak or toast? : 0 1
- Did I ask you to put a tea bag in a kettle or a mug? : 0 1
- Did I ask you to toast a menu or a cracker? : 0 1
- Did I ask you to eat steak or broccoli? : 0 1
- Did I ask you to make apple juice or orange juice? : 0 1
- Did I ask you to throw completed orders out the right or front window? : 0 1
- Did I ask you to boil milk or soap? : 0 1
- Did I ask you to put bacon in the microwave or on the grill? : 0 1
- Did I ask you to complete an order with the fire extinguisher or soap pump? : 0 1
- Did I ask you to cook two pieces or one piece of bacon? : 0 1
- Did I ask you to blend a cactus or a flower pot? : 0 1