Language Related Research
E-ISSN: 2383-0816
https://lrr.modares.ac.ir
https://doi.org/10.52547/LRR.13.5.23
http://dorl.net/dor/20.1001.1.23223081.1401.0.0.160.2

Tarbiat Modares University

Vol. 13, No. 5
pp. 641-671
November & December 2022

Received: 30 January 2022
Received in revised form: 4 May 2022
Accepted: 25 May 2022

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

Learners' Perceptions of Computerized Cognitive Training Transfer to L2 Learning: An Adaptive Case for COVID-19

Samaneh Seyyedabadi[1], *Zohreh Nafissi*[2*], *Reza Rostami*[3], & *Elaheh Sotoudehnama*[4]

Abstract

Cognitive Training (CT) refers to programs designed to enhance the efficiency of cognitive and brain mechanisms through practice and/or intentional instruction. A highly controversial issue in the field of Computerized Cognitive Training (CCT) is its possible transferability to non-trained areas; one untouched discipline is second language (L2) learning. Hence, due to the facilitative role of attention and the predictive strength of working memory in L2 development and comprehension, CCT seems necessary for English language learners. Furthermore, few studies have investigated users' perceptions of potential improvements in their cognitive functioning. To fill such inherent gaps and overcome the imposed barriers of conducting intervention studies during the COVID-19 pandemic era, this study adopted an interdisciplinary approach to explore English language learners' self-perceived Far Transfer (FT) effects of Remote Adaptive Multi-Domain Computerized Cognitive Training (RAMCCT) in general cognitive functioning and L2-specific cognitive functioning. Thus, online observations of L2 receptive skills courses (reading and listening) and synchronous semi-structured interviews were undertaken with a convenience sample of 11 intermediate EFL learners who completed eight weeks of RAMCCT. Thematic Analysis (TA) revealed perceived advances in working memory, attention, multitasking, processing speed, hand-eye/ear coordination in general cognitive functioning, and improvements in either one or both of the L2 receptive skills in terms of attention and comprehension and speed. The results are discussed by the corresponding links between attention, working memory, and multitasking, together with the automatization of the core cognitive processes. Implications address game designers, L2 teachers, teacher training programs, and researchers.

Keywords: computerized cognitive training, far transfer, L2 receptive skills, thematic analysis, COVID-19.

[1] PhD Candidate in TEFL, Department of English, Faculty of Literature, Alzahra University, Tehran, Iran; ORCID ID: https://orcid.org/0000-0001-9276-3109
[2] Corresponding author: Associate Professor in TEFL, Department of English, Faculty of Literature, Alzahra University, Tehran, Iran; ORCID ID: https://orcid.org/0000-0001-7849-6243; *Email:* z.nafisi@alzahra.ac.ir
[3] Professor in Psychology, Department of Psychology, Faculty of Psychology and Education, University of Tehran, Tehran, Iran; ORCID ID: https://orcid.org/0000-0001-9318-108X
[4] Professor in TEFL, Department of English, Faculty of Literature, Alzahra University, Tehran, Iran; ORCID ID: https://orcid.org/0000-0002-0310-9496

of RAMCCT. Thematic Analysis (TA) revealed perceived advances in working memory, attention, multitasking, processing speed, hand-eye/ear coordination in general cognitive functioning, and improvements in either one or both of the L2 receptive skills in terms of attention and comprehension and speed. The results are discussed by the corresponding links between attention, working memory, and multitasking, together with the automatization of the core cognitive processes. Implications address game designers, L2 teachers, teacher training programs, and researchers.

***Keywords*:** computerized cognitive training, far transfer, L2 receptive skills, thematic analysis, COVID-19

1. Introduction

It is beyond doubt that L2 learning has multidisciplinary roots (Gass et al., 2020) in integrating ideas and research strategies from linguistics, psychology, sociology, education, anthropology, and even biology to examine the multifaceted difficulties of describing and explaining how individuals fail and succeed in learning additional languages (Tomlin & Gernsbacher, 1994). One newly emerging field in close relationship with L2 learning is cognitive neuroscience. Since the brain is the origin of all learning, including L2 learning, one may wonder why it is ignored within the language classroom when mental practice makes the brain faster and more responsive (Gibson, 2006), facilitating the language learning process. Language teachers may be either uninformed or unconcerned about the necessity of sharpening the brain in helping L2 learners since they may consider cognition a fixed entity. However, burgeoning evidence concerning neuroplasticity (brain's enduring capacity for change in response to experience or external stimulation (Pappa et al., 2020; Park et al., 2014) and the possibility of cognitive transfer (the generalization of the training-acquired skills across different domains; Sala et al., 2019) accounts for embarking on cognitive training interventions within the field since based on the use it or lose it principle, to keep the brain at its maximum-functioning level, exercising it through cognitive stimulation deems crucial (Wilkinson & Yang, 2016).

Due to the relatively ignored cognitive aspect of L2 learning within language classrooms, teachers who know less about cognitive skills and their possible role in language learning may try different language teaching methodologies to help their students overcome their language learning failures. Nevertheless, no matter how hard teachers try, they may be unsuccessful due to some unknown cognitive failures in their students, which may impede their learning. Aiming to fill the aforementioned inherent gap in the previous body of literature, the present study highlights the significance of the missing link of language learners' cognitive training within the chain of L2 studies. To this end, we adopted a qualitative approach to explore trainees' perceptions of the possible transfer effects of remote adaptive multi-domain computerized cognitive training in their general cognitive functioning and L2-specific functioning via online semi-structured interviews and observations. Therefore, the following research questions were sought:

1. How do L2 learners perceive the transfer effects of RAMCCT in their general cognitive functioning?

2. How do EFL learners perceive the transfer effects of RAMCCT in their L2 receptive skills (reading and listening)?

2. Literature Review

2.1. Cognitive (Brain) Training in a Nutshell

Cognitive Skills are the necessary mental processes responsible for organizing, understanding, and retrieving information. Generally, cognitive (often called "brain") training refers to programs designed to enhance the efficiency of cognitive and brain mechanisms through practice and/or intentional instruction (Gibson, 2006). The brain training programs usually focus on improving the speed and accuracy of perceptual processes through increasing attention, episodic memory, executive function, reasoning, speech, language, or visual-spatial skills (Klimova, 2016).

A healthy brain naturally seeks to perform as efficiently as possible. Like the body that requires physical activity to stay fit and trim, the brain needs mental practice to stay fast and responsive. Therefore, excessive mental exercise forces the brain to re-wire itself via strengthening and reorganizing synapses and making neural pathways perform more efficiently. Since most mental processes happen unconsciously while defining our ability to learn, academic performance depends on cognitive skills functioning. In other words, increasing the brain's capabilities leads to improved academic performance (Gibson, 2006).

Over the last decades, the rapidly growing body of literature on Cognitive Training (CT) interventions has introduced it as a timely issue of high academic and societal relevance. Previous studies show more CT contributions from 2010 onwards (Strobach & Karbach, 2021). Such an excessive interest in CT interventions may be due to the ever-presence of cognitive and neural plasticity even up to very old age (Green et al., 2014).

2.2. Conceptual Framework

Apart from neuroplasticity, various cognitive training interventions rely on two other core concepts while considering the legitimacy and efficacy of training outcomes within a given normal or clinical sample at any age range: cognitive transfer and automaticity.

Transfer is the cornerstone of cognitive training programs that primarily aim at fostering the overall cognitive function or, at least, some general cognitive domains (e.g., memory and processing speed) in an attempt to subsequently advance professional and academic domain-specific skills that rest on them (Sala et al., 2019). Cognitive transfer is a crucial issue to take into consideration when examining the scope and degree of the plastic changes (i.e., training gains) in behavior and learning (Li et al., 2008) and "assessing the real-world utility of a cognitive training or practice program" (Wilkinson & Yang, 2016, p. 208). Transfer can be either near or far based on the degree of overlap between the source and target domains (Sala et al., 2019). While near transfer deals with skills generalized to similar domains, far transfer considers generalizing skills across irrelevant or loosely-related domains (Barnett & Ceci, 2002).

Automaticity is the desired outcome of most cognitive training interventions that follow a process-based approach in enhancing the core cognitive processes to induce learning that is not stimulus- or task-specific (Bellander, 2016). Specifically, process-based CT interventions foster automaticity as they improve the speed and accuracy of perceptual processes through increasing attention, episodic memory, executive functions, reasoning, or visuospatial skills (Klimova, 2016). On the other hand, automaticity is the ability to perform tasks effortlessly and unconsciously with low interference from other simultaneous activities (Poldrack et al., 2005).

2.3. The Role of Cognitive Skills in L2 Learning

According to Mitchell et al. (2013, p.1), L2 is an umbrella term covering any languages learned after the first language, be it a foreign or a second (local) language in one's local region or community, since "the underlying learning processes are essentially the same … despite differing learning purposes and circumstances." They further referred to the internet as a means of communication and language accessibility, destroying local/foreign distinctions. Within the L2 context, researchers have taken some steps to highlight the significant role of cognitive skills in successful language learning. In this regard, attention has been involved in an ongoing debate concerning attention, noticing, and consciousness (awareness) in input processing over the last three decades (Dolgunsöz, 2015). All theoretical foundations in accord have embraced the facilitative role of attention in L2 development by allocating attentional resources to specific linguistic features of the input. However, whether the learner will process the linguistic input (un)consciously (Leow, 2020).

Over the last few years, L2 researchers have been extensively examining the role of Working Memory (WM) in L2 learning (Wen et al., 2015) in an attempt to soften the huge processing and activation that adult language learners experience, which further limits their WM capacities (Sagarra, 2013). WM was found to strongly predict L2 comprehension in adult learners (Alptekin & Erçetin, 2010). Moreover, research has demonstrated the predictive validity of WM for L2 classroom learning (Linck & Weiss, 2015); thus, individuals with more significant

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

WM resources are better equipped to handle the cognitive processing demands of mastering an L2 (Linck et al., 2014).

2.4. Empirical Research

Given the widely recognized possibility of near transfer compared to far transfer, primarily the latter has been the center of dramatic attention, controversy, and exploration for researchers, policymakers, and practitioners (Sala et al., 2019). Several studies have investigated the likelihood of far transfer effects of cognitive training. While some studies have adopted an optimistic outlook in justifying such a possibility (Strobach & Karbach, 2021; Taatgen, 2021), others have relatively questioned it due to the obtained weak effect sizes (Sala & Gobet, 2017; Simons et al., 2016).

Moreover, potential far transfer effects have been controversially explored across various age groups among typically developing individuals and clinical populations. Although some studies have accounted for obtaining far transfer effects of cognitive training in children (Rueda et al., 2021), adults (Brehmer et al., 2012), or both groups (Karbach & Unger, 2014), other studies have rejected the case of training generalizability to untrained tasks at any age group (Bürki et al., 2014; Li et al., 2008). Clinically, the same controversy is still present; some studies have reported promising far transfer effects (Duric et al., 2012; Galbiati et al., 2009), whereas others have dismissed it (Kray et al., 2012). Furthermore, many studies have examined the lasting efficacy of far transfer effects (Ball et al., 2010; Kelly et al., 2014). Last but not least, the targeted cognitive domains in the previous studies were mainly working memory (Au et al., 2015), executive functions (Karbach & Verhaeghen, 2014), or multi-domains (Strobach & Schubert, 2021).

Despite the growing popularity of Computerized Cognitive Training (CCT) and research interest in its far transfer effects to other cognitive domains, the field

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

of L2 learning is still untouched. Building upon the previous body of literature concerning the prominent role of cognitive skills in L2 learning (Alptekin & Erçetin, 2010; Leow, 2020; Linck et al., 2014; Linck & Weiss, 2015), Cognitive Training (CT) seems to be a necessity for English language learners. However, the dearth of CT interventions within the field highlights it as a neglected yet novel topic open for further exploration to grasp the concept better and form a vivid picture of reality. Moreover, trainees' perceptions of the possible far transfer effects of computerized cognitive training in their general cognitive functioning have been ignored. Consequently, in its exploratory nature, the current study aimed to fill such inherent gaps in the literature by adopting a qualitative approach to deeply investigate and capture the forgotten side of trainees' perceptions of transfer effects of RAMCCT within two domains of general cognitive functioning and L2-specific cognitive functioning.

3. Methodology

As a post-graduate student and language teacher, the lead researcher became acquainted with the field of cognitive neuroscience through participating in multiple workshops on brain and cognition, cognitive functions and their assessment, and computerized cognitive training to name but a few. This interest was sparked by concern for a dyslexic L2 learner with significant reading and listening skills difficulties in one of her classes. Moving further, she wondered whether cognitive training might have a facilitative role in improving L2 receptive skills for all L2 learners. Therefore, she devoted her doctoral dissertation to investigating this issue under the supervision and advice of qualified faculty members from both fields. To address L2 learners' perspectives, this study was undertaken through semi-structured interviews and online observation data collection techniques interpreted via thematic analysis.

Due to the lockdown imposed by the COVID-19 pandemic, the present study took some adaptive measures to handle better the constraints of conducting CT studies that will be explained in the following sections.

3.1. Participants

This study utilized an in-class recruited convenience sample (Dörnyei, 2007) of 11 (Mean age = 21.63 years, SD = 3.61, Range = 19-32; all females) sophomore undergraduate L2 learners majoring in Teaching English at Imam Reza International University in Mashhad, a city in the northeast of Iran. Participants unfamiliar with the cognitive field and concepts such as cognitive plasticity and transfer voluntarily took part in the present study by offering extra course credits. They underwent eight weeks of RAMCCT at home (five sessions of 45-60 minutes per week), and their perceptions and experiences were explored through online semi-structured interviews. Sample size criteria were not set a priori, following the saturation principle (Creswell, 2015), whereby gathering new data no longer sparked additional themes or revealed new details for the existing themes. Therefore, data gathering was stopped after conducting 11 interviews since saturation point was achieved, and the data seemed repetitive. Inclusion criteria were intermediate English language proficiency level (B1 level in Common European Framework of Reference for languages; CEFR) as indicated by their Cambridge B2 First Practice Exam scores of 140-160 (Cambridge, 2022), absence of neurological disorders or cognitive impairments based on self-disclosure, no consumption of drugs that may either positively or negatively affect cognitive functioning, intelligence quotient above 80 based on their scores in Raven's Standard Progressive Matrices test, no absence from intervention more than two weeks (10 out of 40 sessions), and access to the personal computer together with high-speed internet connection. Last but not least, the researcher-participant relationship was of an instructor-student type with mutual respect and dedication.

3.2. Data Collection

Because of the ongoing COVID-19 pandemic, traditional in-person cognitive training and data collection methods were not feasible and required to be replaced by remote alternatives. Therefore, to overcome the barriers of the pandemic era, the following means of data collection and cognitive intervention were employed in this study.

Participants' perceptions regarding the far transfer effects of RAMCCT were elicited via online synchronous *semi-structured* interviews (i.e., using a specific set of questions and asking for further clarifications). This type of interview was favored to facilitate the comparison of the participants (Mackey & Gass, 2016). Due to the pandemic outbreak, interview sessions were held online in an audio conference via an open-source virtual classroom platform (BigBlueButton). Along with the interviews, two other data sources guided the formation of a rather vivid picture of reality via data triangulation. First, as their university instructor, the lead researcher observed the participants' L2 performance within two online synchronous receptive skills courses (*Reading Comprehension 3* and *Speaking and Listening 3*) and took some field notes. Second, accompanied by the formal online academic platform, a social media group (Telegram) was formed where the participants could receive instructional videos, training protocols, and announcements in their first language (Persian), along with guidance and help in case of facing technical problems or instructional ambiguities through interacting with peers and the researcher. It was also a place for sharing ideas, feelings, and experiences, especially in passing or failing the highly challenging games. Thus, participants' group and individual interactions with the researcher further added to the depth and richness of the TA and data interpretation.

3.2.1. Remote Adaptive Multi-Domain Computerized Cognitive Training Program

This study utilized one of the available RAMCCT programs in the market, BrainWare SAFARI (https://MyBrainWare.com). This award-winning program has an attractive video-game format. It involves 20 exercises (plays) with 168 progressively challenging levels that comprehensively and simultaneously develop and strengthen 41 cognitive skills under six broad categories: attention, memory, visual processing, auditory processing, sensory integration, and reasoning/logic. Figure 1 displays these targeted cognitive skills categories and subcategories in each game.

One significant feature of this program is its adaptivity to each trainee's actual cognitive status. An adaptive training software primarily considers trainees' errors and reductions in reaction times and immediately adjusts the tasks based on their performance capabilities to guarantee training productivity. Indeed, adaptivity is a crucial yet neglected factor in determining the efficacy of a cognitive training program since non-adaptive training keeps the trainee in an automatic rather than attentive mode that may induce boredom and distraction (Benso et al., 2021). The findings of a recent meta-analysis disclosed the efficiency of adaptive multi-domain training in producing significant training effects at both near and far transfer .

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

Figure 1

Cognitive Skills Developed in BrainWare SAFARI Program

Skill	Ancient Logic and Reasoning	Arrow Point Bridge	Bear Shuffle	Cave Comparisons	Crocodile Recollection	Iguana Lookout	Jumping Jaguar Flash	Jungle Labyrinth	Llama Logic	Memory Mountain	Parroting Colors	Piranha Pass	Rhythm Ribbet	Slithering Symbols	Sky Scanning	Tree Tic Tac Toe	Turtle Recall	Volcanic Patterns	Web Weaving	Whispering Waterfall	Category
Visual Sustained Attention		X	X		X	X	X	X		X		X	X	X	X	X	X	X	X		Attention Skills
Auditory Sustained Attention													X								Attention Skills
Visual Selective Attention		X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X		Attention Skills
Auditory Selective Attention				X									X		X					X	Attention Skills
Divided Attention			X		X	X		X		X	X	X	X			X			X		Attention Skills
Flexible Attention				X	X	X				X	X	X	X		X	X			X		Attention Skills
Visual Discrimination				X	X	X	X			X				X	X			X			Visual Processing Skills
Visual Figure Ground															X			X			Visual Processing Skills
Visual Form Consistency				X					X	X											Visual Processing Skills
Directionality		X		X		X						X				X					Visual Processing Skills
Visual Span		X			X		X							X							Visual Processing Skills
Visual Simultaneous Processing		X		X	X		X			X			X	X				X	X		Visual Processing Skills
Visual Sequential Processing	X	X	X						X				X	X	X						Visual Processing Skills
Visualization		X	X	X	X	X		X		X		X		X	X	X			X	X	Visual Processing Skills
Visual Processing Speed		X	X	X	X	X	X	X		X	X	X	X	X		X		X	X		Visual Processing Skills
Oculomotor Skills						X		X				X			X		X				Sensory Integration
Visual-Motor Integration						X		X					X						X		Sensory Integration
Auditory-Motor Integration		X			X					X	X		X		X			X	X	X	Sensory Integration
Timing-Rhythm		X			X					X	X		X		X			X	X	X	Sensory Integration
Visual-Auditory Integration													X		X						Sensory Integration
Auditory Discrimination															X					X	

Skill	Ancient Logic and Reasoning	Arrow Point Bridge	Bear Shuffle	Cave Comparisons	Crocodile Recollection	Iguana Lookout	Jumping Jaguar Flash	Jungle Labyrinth	Llama Logic	Memory Mountain	Parroting Colors	Piranha Pass	Rhythm Ribbet	Slithering Symbols	Sky Scanning	Tree Tic Tac Toe	Turtle Recall	Volcanic Patterns	Web Weaving	Whispering Waterfall	Category
Auditory Sequential Processing															X					X	Auditory Processing
Auditory Processing Speed													X		X					X	Auditory Processing
Visual Sensory Short-Term Memory		X	X	X	X		X			X	X	X	X	X		X	X	X	X		Memory Skills
Auditory Sensory Short-Term Memory				X									X		X					X	Memory Skills
Visual Immediate Short-Term Memory		X	X	X	X		X			X	X	X	X	X		X	X	X	X		Memory Skills
Auditory Immediate Short-Term Memory				X									X		X					X	Memory Skills
Working Memory			X	X	X					X			X		X	X			X	X	Memory Skills
Visual Spatial Memory			X	X						X	X	X				X		X	X		Memory Skills
Long-Term Memory																	X				Memory Skills
Visual Sequential Memory		X	X										X	X							Memory Skills
Auditory Sequential Memory													X		X						Memory Skills
Visual Simultaneous Memory		X		X	X		X			X				X				X			Memory Skills
Logic	X								X			X				X					Thinking Skills
Reasoning	X								X			X				X					Thinking Skills
Planning								X				X				X					Thinking Skills
Problem Solving	X							X	X			X									Thinking Skills
Strategic Thinking	X							X	X			X				X					Thinking Skills
Visual Thinking	X			X				X	X	X		X				X					Thinking Skills
Conceptual Thinking	X								X												Thinking Skills
Decision Speed				X				X				X				X					Thinking Skills

levels (Nguyen et al., 2019).

Source: (The BrainWare Company, 2013)

Another prominent feature of this program is its remote accessibility and progress monitoring option, which explicitly bypasses the limits and constraints of the pandemic era. Previous CCT programs required in-person participation of all the trainees to receive the training individually within a single computer. Therefore, all participants had to be at the clinic three to five times a week for 50 to 60 minutes each time. Nevertheless, the remote option of the BrainWare SAFARI enables the researcher to keep track of the trainees' progress throughout different game levels by demonstrating their failed/succeeded trials and the allocated time in passing each of the game levels which can further reveal the trainee's cognitive strengths and weaknesses along with the type of cognitively demanding games (i.e., progress criteria were decreased number of failed levels and shortened time performance). It also provides some information regarding the training schedule, such as the number of completed sessions, the time spent in practice/scoring mode, the last completed session, etc.

3.3. Procedure

Initially, participants were added to the social media group. Next, participants were taught how to install the intervention program on their computers to play it at home. Since the game required a high-speed internet connection to transfer and store trainees' progress to its data server, personal accounts were given to each individual. Subsequently, the researcher explained the training protocol whereby they were expected to play five sessions of 45-60 minutes per week at any time of the day for eight weeks (40 sessions, approximately 40 hours). They were free to choose which days to play. If they miss a session, they could compensate for it on their free days. Furthermore, they had to play all the games in unison and in rotation without staying more than 10 minutes in each game or passing more than two game levels per session. Meanwhile, the researcher monitored their daily progress and reminded them if they failed to follow the assigned game schedule or training protocol. Additionally, the researcher observed their L2 performance in their online receptive skills courses.

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

At the end of the training phase, participants took part in online interview sessions conducted individually with each participant in Persian, which they all preferred due to the ease of expressing themselves. Each session took place at a mutually convenient time and lasted about 25 to 60 minutes. Interview sessions were audio-recorded with interviewees' consent for later transcription and analysis. Next, the eleven recorded interviews (358 minutes/ five hours and 58 minutes) were transcribed and analyzed meticulously through a detailed inductive-deductive TA. Taking into account the ethical issues, the interviewer ensured the participants about the confidential nature of the study.

3.4. Data Analysis

Data analysis followed Braun and Clarke's (2006) six steps of thematic analysis using NVivo 12. In the first step of *data familiarization*, the researcher *immersed* herself in the interview data by reading the transcripts repeatedly in search of shared meanings, ideas, and patterns. Following Saldaña's (2016) guidelines, the lead researcher employed initial (open), in vivo, and axial coding procedures that well suited the research questions, the nature of the qualitative data, and the study's goals. Initial codes were inclusively generated and deductively organized within the next two steps based on the research questions into two candidate themes, namely general cognitive functioning and L2-specific cognitive functioning. Throughout the following step, the themes were reviewed and refined in terms of coherence and variations to fit the research questions better. The themes were clearly labeled and cultivated in the fifth stage to fulfill the research aims. Ultimately, the themes were presented coherently and logically, accompanied by vivid exemplifying quotes.

To ensure the reliability and validity of the findings, due to their congruent nature in qualitative research (Golafshani, 2003), this study only considered validity. In other words, as Lincoln and Guba (1985, p. 316) clearly stated, "Since there can be no validity without reliability, a demonstration of the former [validity]

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

is sufficient to establish the latter [reliability]." Consequently, Creswell and Poth's (2018) "validation" approach was undertaken by employing two of the validity lenses (i.e., the researcher's lens and participant's lens) that are the most prominent and affordable procedures. Regarding the researcher's lens, the researcher substantiated the findings through triangulation of multiple data sources, such as interviews, participants' progress reports delivered by the software's data server, observation of participants' in-class performance within their receptive skills courses, field notes, along with social media group and individual interactions between the participants and the researcher. To explore the participant's lens, member checking and participant feedback were utilized (Merriam & Tisdell, 2015) as "the most critical technique for establishing credibility" of the findings and interpretations (Lincoln & Guba, 1985, p. 314). As Creswell (2015) suggested, the researcher returned all of the extracted themes and their interpretations to one of the participants to judge their accuracy and credibility.

4. Findings

L2 learners' perceptions of far transfer effects of remote adaptive multi-domain computerized cognitive training is presented based on the research questions in the following sections (see Table 1 for the summary of extracted themes).

Table 1

Extracted Themes from Research Questions

Research questions	Themes
RQ1. How do L2 learners perceive the transfer effects of RAMCCT in their general cognitive functioning?	1. Improved WM 2. Multitasking 3. Advanced visual and auditory attention 4. Increased attention span
RQ2. How do EFL learners perceive the transfer effects of RAMCCT in their L2 receptive skills (reading and listening)?	*Listening:* 1. Greater attention to details 2. Advanced listening comprehension 3. Faster performance in timed language exams *Reading:*

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

Research questions	Themes	
	1.	Greater attention to details
	2.	Faster reading performance
	3.	Increased comprehension

4.1. General Cognitive Functioning

As mentioned earlier, the utilized computerized cognitive training program in this study (BrainWare SAFARI) targets six broad cognitive categories (attention, memory, visual processing, auditory processing, sensory integration, and reasoning/logic) with their related subcategories in each game (Figure 1). To a more or lesser degree, participants perceived and reported generalized training (far transfer) effects of some of these cognitive skills in their general cognitive functions while doing routine life activities such as memorizing various things or multitasking activities. For instance, 82% of the participants pointed out that their WM span and duration have been expanded dramatically. As one of them elaborated, "*My memory span has been strengthened largely to the extent that I can easily remember it even by looking at a six-digit number. I can memorize digit codes and phone numbers quickly and keep them longer in my memory.*" Additionally, another interviewee stated, "*I no longer lag, nor do I ask for repetition while taking notes in class. I can restore information for a longer period in my mind.*" Moreover, easy and quick memorization of word spellings and meanings was perceived.

Seventy-three percent of the participants reported advances in visual and auditory attention that made them more attentive to what they see and hear. Moreover, one of them believed that her reaction to sounds had been multiplied. She illustrated her point: "*Whenever I hear a sound, I look for the place and source it comes from.*" Furthermore, one of them who had suffered from short attention span noticed increased sustained attention in herself and clarified:

My concentration has been dramatically boosted after playing with the program. Previously, after a short time of studying, I had to take a break by walking around

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

and changing my place, getting up to drink a glass of water, or moving my muscles, and then return to studying to regain focus… I had a short concentration span. I could not stay focused on a topic or task despite learning quickly. So, long exams made me very exhausted… at the end of the exam, even when I knew the answers, I could not concentrate because I was sitting for too long. When I worked with the software, I could spend more time on it… and remain focused because of its attraction. Now, it would be much easier for me to use my mind for a complete hour studying or taking an exam.

Less than 20% of the interviewees claimed to gain multitasking ability after their CT experience, which can be regarded as proof of increased attention and WM (Anguera et al., 2013): "*Formerly, I could concentrate only on one thing at a time, but now, I can concentrate on many tasks simultaneously*. *For example, I can read TV subtitles while talking on the phone.*" They believed that it might be due to the progressively challenging nature of the program: "*The game was well-programmed in getting progressively challenging. It became faster after passing each level while requiring more attention and concentration. For instance, while a level required visual or auditory attention, the next level would mix both.*"

Due to the initial cognitive differences between individuals, participants might have experienced some advances in their general cognitive functioning compared to their baseline status. Participants with weaker cognitive abilities benefited more and perceived dramatic changes. For instance, participants with self-reported initial strong working memory in memorizing digits believed that the scope of perceived changes in this domain was limited, while those with self-reported lower initial working memory perceived remarkable improvements. Altogether, participants believed that the CCT program positively influenced their mental functioning: "*I feel my mind has a sense of freshness and vitality now as if it has been well nurtured and nourished.*" Last but not least, boosted processing speed and hand-eye/ear coordination through progressively challenging timed games and sensory integrated training was also touched upon: "*The game has strengthened my mind* *through accelerating my mental agility and reflexes, as well as coordinating my hands, eyes, and ears together.*"

4.2. L2-Specific Cognitive Functioning

To the researchers' best knowledge, the possibility of far transfer effect(s) of RAMCCT in L2 learning has not been explored yet. To fill the gap in the literature, thematic analysis of the interview and observation data revealed some far transfer effects in L2 receptive skills (listening and reading).

Regarding L2 listening, 82% of the interviewees had perceived improvements in their attention, concentration, comprehension, and speed. They had seen a shift toward being more attentive to the details of listening files: "*Before my experience with the software, I could hardly recall the details of the listening tracks or even some of their major points*." Likewise, one of the participants stated that she could pay more attention to the details of conversations in audio files, especially to the speakers with accented and fast speech. She further referred to advances in her listening comprehension:

"*[Previously] I could not understand anything from the listening tasks... I listened to each track three or four times and found the minor points to understand what the speakers meant. However, I can easily understand them by listening to them only twice.*"

Moreover, participants were more attentive to listening test items and more well-concerned about time limitations in timed language exams. As can be seen in Figure 1, 45% of the games target *timing and rhythm* cognitive skills. Noteworthily, as revealed by the participants in the interviews and social media group, along with the program's remote progress reports, most participants initially had difficulty doing such games, especially those requiring clicking to the metronome beat while simultaneously memorizing something or doing another task. However, participants could manage their anxiety and improve their attention and concentration through regular practice and progressive challenges. A similar process occurs in L2 listening activities; language learners listen to something while simultaneously reading and answering the questions or filling in the blanks with the appropriate words heard throughout the audio files. Thus, bearing such similarities, the perceived advances in L2 listening could be justified.

Within L2 reading, 64% of the participants reported advances in their attention, comprehension, and speed. Interviewees believed they tended to pay more attention to text details after the training phase. Moreover, they had seen a shift toward being faster readers in timed language exams: "*I used to be a slow reader. I was either careless about time or so concerned about it to fall behind the text … I have become a faster reader while paying more attention to keywords.*" Notably, among the trained cognitive skills within the present study (Figure 1), *visual processing speed* present in 75% of the games appears to be more associated with reading speed. It is the ability to scan, examine, and compare the received visual stimuli quickly (BrainWare Learning Company, 2019). In such plays, the trainee must search for digits, letters, or differences among several other existing stimuli. Likewise, in L2 reading tasks, language learners must rapidly find some information from the text. Consequently, gaining such advances toward faster L2 reading performance is justified through the underlying similarity between the reading skill and visual processing speed. Furthermore, one of the interviewees had perceived some progress in her reading comprehension. Last but not least, as a result of gaining multitasking ability throughout the training phase, one of the interviewees referred to its far linguistic transfer: "*[Previously] I could not read and listen simultaneously, but I can do it now... [and] remain focused on both.*"

Noteworthily, 54% of the participants reported FT effects of CCT on both receptive skills. In contrast, two of them could not perceive any training generalizability in L2 learning as they assumed only language practice could foster L2 proficiency. Furthermore, two of the three remaining trainees believed in transfer effects only in listening skills. Last but not least, congruent with the interview data, the researcher's field notes of observing the participants' L2 progress revealed their faster performance and greater attention to details of both visual and auditory texts, as were evident in their reading and listening comprehension check assessments.

5. Discussion and Conclusion

This study explored L2 learners' perceptions of far transfer effects of RAMCCT in general cognitive functioning and L2-specific cognitive functioning. The findings indicated some perceived improvements in general cognitive functioning, such as memorizing (e.g., phone numbers or digit codes), multitasking, more significant and more prolonged concentration while studying and taking exams, and better performance in timed language exams. Moreover, interviewees noticed increased visual and auditory attention, which made them more attentive to audiovisual stimuli in their surroundings. Such results may be in part due to the presence of some dual- or multitask game levels within the utilized cognitive training program since previous research demonstrated increased transfer effects of either dual-task training or hybrid training, integrating both single-task and dual-task conditions, to untrained dual tasks (Liepelt et al., 2011) and measures of sustained attention and working memory (Anguera et al., 2013). Furthermore, these findings may be obtained out of enormous working memory practice games in the program, considering the highly predictive role of WM in multitasking ability relative to other cognitive, behavioral, and experienced-based variables (Redick, 2016). Additionally, given the closely related nature of WM and attentional processes that underlie several various cognitive functions (Awh et al., 2006), it is likely that intense integrated practice in these two domains, as seen in most of the games in the utilized program, might account for such improvements. Accordingly, the obtained results are against previous studies that dismissed the possibility of gaining FT effects (Owen et al., 2010; Simons et al., 2016).

Further, the study's findings revealed perceived improvements in either one of the

[DOR: 20.1001.1.23223081.1401.0.0.160.2]

L2 receptive skills in terms of attention, comprehension, and speed. In its illuminative nature of highlighting the role of cognitive skills in L2 learning, this finding is congruent with a recent Event-Related Potential (ERP) study investigating the role of domain-general neuro-cognitive systems in language acquisition and comprehension (Barkley, 2015). As Barkley demonstrated, brain responses that may initially seem language-specific can instead list general cognitive processes such as working memory, attention, meaning construction, and the processing of structured hierarchical sequences. Utilizing such general cognitive processes occurs in skilled reading, which requires lower-level processing of visual input, matching symbolic representations (e.g., graphemes such as "sh" in sham) to auditory and semantic word memories, and higher-level processing of meaning or comprehension (Fiorello et al., 2006). Furthermore, the obtained outcome in this study is in accord with L2 studies that unanimously maintain the central role of WM in language comprehension (Mitchell et al., 2019). For instance, WM extracts information from the text and integrates it with prior knowledge to create meaning as an integral part of reading comprehension. However, given the limited processing capacity of WM, a more economical allocation of attentional resources is required through automaticity (Gass et al., 2013), which builds upon attention, WM, and processing speed based on Gibson's (2006) learning model whereby successful learning entails coordination and cooperation between the automatic/active processing and higher thinking cognitive skills. Thus, all learning involves utilizing an automatic process of classifying information as either new or already known to decrease the cognitive load on working memory and enable higher-order information processing (Gibson, 2006; Jedlicka, 2012). As mentioned previously, obtaining such automaticity in core cognitive processes is the goal of computerized cognitive training programs. Thus, for those participants with perceived improvements in their receptive skills, such underlying cognitive skills might have been further strengthened to release capacity in WM for other language-specific functions. Last but not least, the obtained perceived FT effects in receptive skills were against the findings of studies that did not account for improvements in L2 learning (Hayashi, 2019; Hayashi et al., 2016).

Concerning the somewhat neglected cognitive bedrock of L2 learning, the results of this study can be an eye-opener for L2 teachers to consider cognitive and linguistic factors while pinpointing the possible roots of L2 learners' success and/or failure in facilitating the L2 learning process. In addition, the findings could provide food for thought for teacher training programs to add cognitively oriented topics to their current English language teaching curricula since language teachers without sufficient knowledge concerning cognitive skills and their role in L2 learning may try different teaching methodologies to help their students overcome their language learning failures. However, they may be unsuccessful due to some unknown cognitive failures in their students, which impede their other kinds of learning. Moreover, given the highlighted benefits of integrated CCT, game designers could develop more integrated, multi-domain products rather than the mere exclusive alternatives such as those targeting WM, attention, fluid intelligence, and cognitive flexibility, to name but a few. Last but not least, in light of the adopted procedure in this study, researchers could get some ideas on how to conduct remote CCT studies.

The qualitative nature and the limited scope of this study require cautious interpretation of its preliminary findings without any attempt to generalize them. Nevertheless, it could be a springboard for further research and future studies in addressing the role of various CCT program types, duration of intervention together with its length and frequency, language proficiency levels, learner attributes, and L2 skills and sub-skills, to name but a few.

Acknowledgments

We acknowledge and appreciate the students and staff of Imam Reza International University for their participation and cooperation. This work would not have been possible without the generosity and support of the BrainWare Learning Company (https://MyBrainWare.com), who provided a license of their software to us free of charge. Also, we are grateful to the experts and staff of Atieh Clinical Neuroscience Center (https://AtiehClinic.com) for their support and technical advice.

References

Alptekin, C., & Erçetin, G. (2010). The role of L1 and L2 working memory in literal and inferential comprehension in L2 reading. *Journal of Research in Reading*, *33*(2), 206–219. https://doi.org/10.1111/j.1467-9817.2009.01412.x

Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., Kong, E., Larraburo, Y., Rolle, C., Johnston, E., & Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*, *501*(7465), 97–101. https://doi.org/10.1038/nature12486

Au, J., Sheehan, E., Tsai, N., Duncan, G. J., Buschkuehl, M., & Jaeggi, S. M. (2015). Improving fluid intelligence with training on working memory: A meta-analysis. *Psychonomic Bulletin and Review*, *22*(2), 366–377. https://doi.org/10.3758/s13423-014-0699-x

Awh, E., Vogel, E. K., & Oh, S. H. (2006). Interactions between attention and working memory. *Neuroscience*, *139*(1), 201–208. https://doi.org/10.1016/j.neuroscience.2005.08.023

Ball, K., Edwards, J. D., Ross, L. A., & McGwin, G. (2010). Cognitive training decreases motor vehicle collision involvement of older drivers. *Journal of the American Geriatrics Society*, *58*(11), 2107–2113. https://doi.org/10.1111/j.1532-5415.2010.03138.x

Barkley, C. M. (2015). *Event-related potential (ERP) studies of the role of working memory, selective attention, and attentional efficiency in language acquisition and comprehension* (Publication No. 3718399) [Doctoral dissertation, University of California, San Diego]. ProQuest Dissertations and Theses. https://escholarship.org/uc/item/2n69z73n

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin*, *128*(4), 612–637. https://doi.org/10.1037/0033-2909.128.4.612

Bellander, M. (2016). *Plasticity of memory functioning: Genetic predictors and brain changes* [Doctoral dissertation, Karolinska Institute]. https://core.ac.uk/download/pdf/70344170.pdf

Benso, F., Moretti, S., Bellazzini, V., Benso, E., Ardu, E., & Gazzellini, S. (2021). Principles of integrated cognitive training for executive attention: Application to an instrumental skill. *Frontiers in Psychology*, *12*, 1–20. https://doi.org/10.3389/fpsyg.2021.647749

BrainWare Learning Company. (2019, November). *BrainWare SAFARI cognitive skills definitions*. https://MyBrainWare.com

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brehmer, Y., Westerberg, H., & Bäckman, L. (2012). Working-memory training in younger and older adults: Training gains, transfer, and maintenance. *Frontiers in Human Neuroscience*, *6*, 1–7. https://doi.org/10.3389/fnhum.2012.00063

Bürki, C. N., Ludwig, C., Chicherio, C., & de Ribaupierre, A. (2014). Individual differences in cognitive plasticity: An investigation of training curves in younger and older adults. *Psychological Research*, *78*(6), 821–835. https://doi.org/10.1007/s00426-014-0559-3

Cambridge. (2022). *Cambridge Assessment English*. https://www.cambridgeenglish.org/we-are/centres/

Creswell, J. W. (2015). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (5th ed.). Pearson.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE.

Dolgunsöz, E. (2015). Measuring attention in second language reading using eyetracking: The case of the noticing hypothesis. *Journal of Eye Movement Research*, *8*(5), 1–18. https://doi.org/10.16910/jemr.8.5.4

Dörnyei, Z. (2007). *Research methods in applied linguistics*. Oxford University Press.

Duric, N. S., Assmus, J., Gundersen, D., & Elgen, I. B. (2012). Neurofeedback for the treatment of children and adolescents with ADHD: A randomized and controlled clinical trial using parental reports. *BMC Psychiatry*, *12*(1), 1–8. https://doi.org/10.1186/1471-244X-12-107

Fiorello, C. A., Hale, J. B., & Snyder, L. E. (2006). Cognitive hypothesis testing and response to intervention for children with reading problems. *Psychology in the Schools*, *43*(8), 835–853. https://doi.org/10.1002/pits.20192

Galbiati, S., Recla, M., Pastore, V., Liscio, M., Bardoni, A., Castelli, E., & Strazzer, S. (2009). Attention remediation following traumatic brain injury in childhood and adolescence. *Neuropsychology*, *23*(1), 40–49. https://doi.org/10.1037/a0013409

Gass, S. M., Behney, J., & Plonsky, L. (2013). *Second language acquisition: An introductory course* (4th ed.). Routledge. https://doi.org/10.4324/9780203137093

Gass, S. M., Behney, J., & Plonsky, L. (2020). *Second language acquisition: An introductory course* (5th ed.). Routledge. https://doi.org/10.4324/9781315181752

Gibson, K. (2006). *Unlock the Einstein inside: Applying new brain science to wake up the smart in your child*. LearningRx.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, *8*(4), 597–607. https://doi.org/10.46743/2160-3715/2003.1870

Green, C. S., Strobach, T., & Schubert, T. (2014). On methodological standards in training and transfer experiments. *Psychological Research*, *78*(6), 756–772. https://doi.org/10.1007/s00426-013-0535-3

Hayashi, Y. (2019). Investigating effects of working memory training on foreign language development. *Modern Language Journal*, *103*(3), 665–685. https://doi.org/10.1111/modl.12584

Hayashi, Y., Kobayashi, T., & Toyoshige, T. (2016). Investigating the relative contributions of computerised working memory training and English language teaching to cognitive and foreign language development. *Applied Cognitive Psychology*, *30*(2), 196–213. https://doi.org/10.1002/acp.3177

Jedlicka, E. J. (2012). *The real-life benefits of cognitive training* (Publication No. 3519139) [Doctoral dissertation, Capella University]. ProQuest Dissertations and Theses.

Karbach, J., & Unger, K. (2014). Executive control training from middle childhood to adolescence. *Frontiers in Psychology*, *5*, 1–14. https://doi.org/10.3389/fpsyg.2014.00390

Karbach, J., & Verhaeghen, P. (2014). Making working memory work: A meta-analysis of executive control and working memory training in older adults. *Psychological Science*, *25*(11), 2027–2037. https://doi.org/10.1177/0956797614548725

Kelly, M. E., Loughrey, D., Lawlor, B. A., Robertson, I. H., Walsh, C., & Brennan, S. (2014). The impact of cognitive training and mental stimulation on cognitive and everyday functioning of healthy older adults: A systematic review and meta-analysis. *Ageing Research Reviews*, *15*(1), 28–43. https://doi.org/10.1016/j.arr.2014.02.004

Klimova, B. (2016). Computer-based cognitive training in aging. *Frontiers in Aging Neuroscience*, *8*, 1–6. https://doi.org/10.3389/fnagi.2016.00313

Kray, J., Karbach, J., Haenig, S., & Freitag, C. (2012). Can task-switching training enhance executive control functioning in children with attention deficit/-hyperactivity disorder? *Frontiers in Human Neuroscience*, *5*, 1–9. https://doi.org/10.3389/fnhum.2011.00180

Leow, R. P. (2020). Attention, noticing, and awareness in second language acquisition. In C. A. Chapelle (Ed.), *The encyclopedia of applied linguistics* (pp. 269–275). Wiley-Blackwell. https://doi.org/10.1002/9781405198431.wbeal0058.pub2

Li, S. C., Schmiedek, F., Huxhold, O., Röcke, C., Smith, J., & Lindenberger, U. (2008). Working memory plasticity in old age: Practice gain, transfer, and maintenance. *Psychology and Aging*, *23*(4), 731–742. https://doi.org/10.1037/a0014343

Liepelt, R., Strobach, T., Frensch, P., & Schubert, T. (2011). Improved intertask coordination after extensive dual-task practice. *Quarterly Journal of Experimental Psychology*, *64*(7), 1251–1272. https://doi.org/10.1080/17470218.2010.543284

Linck, J. A., Osthus, P., Koeth, J. T., & Bunting, M. F. (2014). Working memory and second language comprehension and production: A meta-analysis. *Psychonomic Bulletin and Review*, *21*(4), 861–883. https://doi.org/10.3758/s13423-013-0565-2

Linck, J. A., & Weiss, D. J. (2015). Can working memory and inhibitory control predict second language learning in the classroom? *SAGE Open*, *5*(4), 1–11. https://doi.org/10.1177/2158244015607352

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. SAGE.

Mackey, A., & Gass, S. M. (2016). *Second language research: Methodology and design* (2nd ed.). Routledge. https://doi.org/10.4324/9781315750606

Merriam, S., & Tisdell, E. (2015). *Qualitative research: A guide to design and* *implementation* (4th ed.). Wiley.

Mitchell, R., Myles, F., & Marsden, E. (2013). *Second language learning theories* (3rd ed.). Routledge. https://doi.org/10.4324/9780203770795

Mitchell, R., Myles, F., & Marsden, E. (2019). *Second language learning theories* (4th ed.). Routledge. https://doi.org/10.4324/9781315617046

Nguyen, L., Murphy, K., & Andrews, G. (2019). Immediate and long-term efficacy of executive functions cognitive training in older adults: A systematic review and meta-analysis. *Psychological Bulletin*, *145*(7), 698–733. https://doi.org/10.1037/bul0000196

Owen, A. M., Hampshire, A., Grahn, J. A., Stenton, R., Dajani, S., Burns, A. S., Howard, R. J., & Ballard, C. G. (2010). Putting brain training to the test. *Nature*, *465*(7299), 775–778. https://doi.org/10.1038/nature09042

Pappa, K., Biswas, V., Flegal, K. E., Evans, J. J., & Baylan, S. (2020). Working memory updating training promotes plasticity and behavioural gains: A systematic review and meta-analysis. *Neuroscience and Biobehavioral Reviews*, *118*, 209–235. https://doi.org/10.1016/j.neubiorev.2020.07.027

Park, D. C., Lodi-Smith, J., Drew, L., Haber, S., Hebrank, A., Bischof, G. N., & Aamodt, W. (2014). The impact of sustained engagement on cognitive function in older adults: The synapse project. *Psychological Science*, *25*(1), 103–112. https://doi.org/10.1177/0956797613499592

Poldrack, R. A., Sabb, F. W., Foerde, K., Tom, S. M., Asarnow, R. F., Bookheimer, S. Y., & Knowlton, B. J. (2005). The neural correlates of motor skill automaticity. *Journal of Neuroscience*, *25*(22), 5356–5364. https://doi.org/10.1523/JNEUROSCI.3880-04.2005

Redick, T. S. (2016). On the relation of working memory and multitasking: Memory span and synthetic work performance. *Journal of Applied Research in*

Memory and Cognition, *5*(4), 401–409. https://doi.org/10.1016/j.jarmac.2016.05.003

Rueda, M. R., Cómbita, L. M., & Pozuelos, J. P. (2021). Cognitive training in childhood and adolescence. In T. Strobach & J. Karbach (Eds.), *Cognitive training* (2nd ed., pp. 127–139). Springer. https://doi.org/10.1007/978-3-030-39292-5_9

Sagarra, N. (2013). Working memory in second language acquisition. In C. A. Chapelle (Ed.), *The encyclopedia of applied linguistics* (pp. 6207–6215). Wiley-Blackwell. https://doi.org/10.1002/9781405198431.wbeal1286

Sala, G., Deniz Aksayli, N., Semir Tatlidil, K., Tatsumi, T., Gondo, Y., & Gobet, F. (2019). Near and far transfer in cognitive training: A second-order meta-analysis. *Collabra: Psychology*, *5*(1), 1–22. https://doi.org/10.1525/collabra.203

Sala, G., & Gobet, F. (2017). Does far transfer exist? Negative evidence from chess, music, and working memory training. *Current Directions in Psychological Science*, *26*(6), 515–520. https://doi.org/10.1177/0963721417712760

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). SAGE.

Simons, D. J., Boot, W. R., Charness, N., Gathercole, S. E., Chabris, C. F., Hambrick, D. Z., & Stine-Morrow, E. A. L. (2016). Do "brain-training" programs work? *Psychological Science in the Public Interest*, *17*(3), 103–186. https://doi.org/10.1177/1529100616661983

Strobach, T., & Karbach, J. (2021). Introduction. In T. Strobach & J. Karbach (Eds.), *Cognitive training* (2nd ed., pp. 1–8). Springer. https://doi.org/10.1007/978-3-030-39292-5_1

Strobach, T., & Schubert, T. (2021). Video game training and effects on executive functions. In T. Strobach & J. Karbach (Eds.), *Cognitive training* (2nd ed., pp. 229–241). Springer. https://doi.org/10.1007/978-3-030-39292-5_16

Taatgen, N. A. (2021). Theoretical models of training and transfer effects. In T. Strobach & J. Karbach (Eds.), *Cognitive training* (2nd ed., pp. 41–54). Springer. https://doi.org/10.1007/978-3-030-39292-5_4

The BrainWare Company. (2013). *Cognitive skills developed in BrainWare SAFARI*.

Tomlin, R. S., & Gernsbacher, M. (1994). Cognitive foundations of second language acquisition. *Studies in Second Language Acquisition*, *16*(2), 129–132. https://doi.org/10.1017/S0272263100012833

Wen, Z., Mota, M. B., & McNeill, A. (2015). Introduction and overview. In Z. Wen, M. B. Mota, & A. McNeill (Eds.), *Working memory in second language acquisition and processing* (pp. 1–14). Multilingual Matters. https://doi.org/10.21832/9781783093595-004

Wilkinson, A. J., & Yang, L. (2016). Cognitive plasticity. In S. K. Whitbourne (Ed.), *The encyclopedia of adulthood and aging* (pp. 206–209). Wiley. https://doi.org/10.1002/9781118521373.wbeaa327

About the Authors

Samaneh Seyyedabadi is a PhD candidate in TEFL at Alzahra University. She has been teaching BA and MA courses in TEFL at Imam Reza International University as well as Islamic Azad University of Mashhad. Her major research interests are cognitive psychology, language skills and sub-skills, and positive psychology.

Zohreh Nafissi is an Associate Professor of TEFL at Alzahra University, where she has been teaching for the past 24 years. She has presented more than 45 papers at (inter)national conferences, has published extensively and supervised numerous dissertations. Her main research interests are teachers' professional development, identity, and the intersection of language and ethical education.

Reza Rostami is a Professor in Psychology at University of Tehran. He is also the founder and chairman of Atieh Clinical Neuroscience Center, the first comprehensive neuro- and psych center with new therapeutic approaches in Iran. He has published more than 140 articles in national and international journals. He has been working as a researcher in the Brain Stimulation Lab at the Medical University of South California. His research and professional interests are brain imaging, brain stimulation, clinical application of neuroscientific methods in psychiatry, together with cognitive and clinical neuroscience.

Elaheh Sotoudehnama holds PhD in TEFL and has been teaching for more than 30 years in the Department of English Language at Alzahra University in Iran being a full professor. Her areas of interest include psycholinguistics, culture, skills, and sub-skills and she has published many international and national articles in these fields.

[DOR: 20.1001.1.23223081.1401.0.0.160.2]