

## Synchrony in Old Age: Playing the Mirror Game Improves Cognitive Performance

Shoshi Keisari, Rinat Feniger-Schaal, Yuval Palgi, Yulia Golland, Anat Gesser-Edelsburg & Boaz Ben-David

To cite this article: Shoshi Keisari, Rinat Feniger-Schaal, Yuval Palgi, Yulia Golland, Anat Gesser-Edelsburg & Boaz Ben-David (2022) Synchrony in Old Age: Playing the Mirror Game Improves Cognitive Performance, *Clinical Gerontologist*, 45:2, 312-326, DOI: [10.1080/07317115.2020.1799131](https://doi.org/10.1080/07317115.2020.1799131)

To link to this article: <https://doi.org/10.1080/07317115.2020.1799131>



Published online: 06 Aug 2020.



Submit your article to this journal [↗](#)



Article views: 375







View related articles [↗](#)



View Crossmark data [↗](#)



## Synchrony in Old Age: Playing the Mirror Game Improves Cognitive Performance

Shoshi Keisari PhD <sup>a\*</sup>, Rinat Feniger-Schaal Ph.D.<sup>b\*</sup>, Yuval Palgi PhD <sup>a,c</sup>, Yulia Golland PhD<sup>d</sup>, Anat Gesser-Edelsburg PhD <sup>e</sup>, and Boaz Ben-David PhD <sup>f,g</sup>

<sup>a</sup>Department of Gerontology, University of Haifa, Haifa, Israel; <sup>b</sup>School of Creative Arts Therapies, The Center for the Study of Child Development, University of Haifa, Haifa, Israel; <sup>c</sup>The Center for Research and Study of Aging, University of Haifa, Haifa, Israel; <sup>d</sup>Sagol Center for Brain and Mind, Baruch Ivcher School of Psychology, Interdisciplinary Center (IDC) Herzliya, Herzliya, Israel; <sup>e</sup>School of Public Health and the Health and Risk Communication Research Center, University of Haifa, Haifa, Israel; <sup>f</sup>Baruch Ivcher School of Psychology, The Interdisciplinary Center (IDC) Herzliya, Herzliya, Israel; <sup>g</sup>Department of Speech-language Pathology, University of Toronto, Toronto, Canada

### ABSTRACT

**Objectives:** Studies have shown that synchronized motion between people positively affects a range of emotional and social functions. The mirror-game is a synchrony-based paradigm, common to theater, performance arts, and therapy, which includes dyadic synchronized motion, playfulness, and spontaneity. The goal of the current study is to examine the effects of the mirror-game on subjective and cognitive indices in late life.

**Methods:** Thirty-four older adults (aged 71–98) participated in a within-group study design. Participants conducted two sessions of 9-minute movement activities: the mirror-game and the control condition – a physical exercise class. Several measures were taken before and after experimental sessions to assess socio-emotional and attentional functions.

**Results:** The mirror-game enhanced performance on the attention sub-scale and led to faster detections of spoken words in noise. Further, it enhanced perceived partner responsiveness and led to an increase in positive reported experience.

**Conclusions:** Our preliminary findings suggest that the mirror-game, rather than the exercise class, may have an immediate impact on mood and some attentional functions.

**Clinical implications:** The mirror-game is a novel intervention, with potential benefits of social-emotional and cognitive functioning, which can be easily implemented into the daily routine care of older adults. Future studies should explore the effect of the mirror-game on additional cognitive and socio-emotional aspects.

### KEYWORDS



Mirror game; synchrony; older adults; attention; playfulness; intervention; exercise; perceived partner responsiveness

## Introduction

In the past two decades, research-based evidence emerged on the role of positive mental health and social interactions to preserve cognitive performance and well-being in aging (e.g., Huppert, 2009; Livingston et al., 2017). Given the role of social interaction and mood in cognitive resilience, there is a need to develop interventions that specifically target these factors (World Health Organization, 2015, 2017). In that sense, the literature on the effects of synchrony make a notable contribution. Manipulating synchronized motion between people was found to positively affect a range of emotional and social functions. Examples include reduction of negative affect (e.g., Fessler & Holbrook, 2014), improvement of perceived and behavioral social bonding (e.g., Reddish, Fischer,

& Bulbulia, 2013), and enhancement of a range of social cognitions (attention, memory, theory of mind – e.g., Baimel et al., 2015; Miles, Nind, Henderson, & Macrae, 2010; Rennung & Görizt, 2016; for a meta-analysis, see Mogan, Fischer, & Bulbulia, 2017).

One of the paradigms to induce synchronized movement in the clinic and the lab is the *Mirror-Game* – a common exercise in theater, dance, and drama therapy. The mirror game is based on dyadic synchronized movement, and also involves playfulness and spontaneity. The goal of the current study was to examine the effects of a short, condensed interpersonal intervention of the mirror-game on subjective ratings of emotional and interpersonal experience in older adults, as well as on basic

**CONTACT** Boaz Ben-David  [boaz.ben.david@idc.ac.il](mailto:boaz.ben.david@idc.ac.il)  Communication, Aging and Neuropsychology Lab (CAN Lab), Baruch Ivcher School of Psychology, Interdisciplinary Center (IDC) Herzliya, Herzliya 4610101, Israel

\*These authors contributed equally to this work.

This article has been republished with minor changes. These changes do not impact the academic content of the article.

© 2020 Taylor & Francis Group, LLC

attentional measures (a standardized test and a daily life task).

Research on the role and value of interpersonal synchrony has become prominent, resulting in extensive literature on the subject (Vicaria & Dickens, 2016) indicating its positive effect on varied functioning as detailed below. Interpersonal motion synchrony arises when the movement of two (or more) individuals becomes temporally coupled. Research shows that people fall into synchronous motion automatically and without explicit goal or benefit (Sebanz, Bekkering, & Knoblich, 2006). Furthermore, synchronous motion plays an important role in social communication and pro-social behavior (Van Baaren, Holland, Kawakami, & Van Knippenberg, 2004). For example, studies have shown that synchrony of body movements, such as tapping (Hove & Risen, 2009), walking together (Wiltermuth & Heath, 2009) or breathing together (Sharon-David, Mizrahi, Rinott, Golland, & Birnbaum, 2018), can increase a sense of intimacy, belonging, and cooperation and is a part of building healthy interactions (Julien, Brault, Chartrand, & Bégin, 2000). A recent meta-analysis (Mogan et al., 2017) summarized 42 studies that used experimentally manipulated synchronous actions and showed their effect on social cognition (such as attention, memory, theory of mind, perceptual sensitivity of a task and perceptions of freedom), positive affect, perceived social bonding (such as trust, entitativity, interconnectedness, closeness, attraction, similarity, liking, affiliation, rapport, social cohesion, feelings of belonging and identification), and behavioral social bonding (as direct behavioral indicators of cooperation and pro-sociality). However, none of these studies examined the effect of interpersonal synchrony in late life. Such examination is highly important when taking into consideration the role of social engagement and positive emotion to preserve cognitive performance, longevity, and health in late life (e.g., Diener & Chan, 2011; Haslam, Cruwys, & Haslam, 2014; Krueger et al., 2009; Xu & Roberts, 2010). The goal of the current study is to test the immediate effects of such a brief intervention in old age.

### **The mirror-game**

One of the paradigms used to study interpersonal synchrony is the mirror-game. The mirror-game is a simple exercise, in which two people imitate each

other's movements while taking turns as leader and follower. The mirror-game is commonly practiced in theater, drama therapy (e.g., Boal, 2013), and dance/movement therapy (McGarry & Russo, 2011). It is used to enhance empathy and emotional understanding of others, and to promote participants' ability to enter and remain in a state of togetherness (Schechner, 1994). Players imitate each other's movements in three rounds, making it possible to experience different roles and interactions. In the first round, one player leads and the other follows; in the second round, they switch roles; and in the last round, both players try to make movements together without deciding who is leading and who is following (similar to a fluent conversation, but in movement).

One of the early studies on the mirror-game found that participants showed intervals of "togetherness motion" in which motion was complex, smooth, and synchronized (Noy, Dekel, & Alon, 2011). This study was the beginning of a scrutinized examination of the mirror-game as a scientific paradigm. Subsequent works found correlations between physiological parameters and the experience of togetherness in the mirror-game. In one study for example, rounds of the mirror-game with high rates of togetherness were characterized by increased cardiovascular activity, increased correlation of players' heart rates, and increased motion intensity (Noy, Levit-Binun, & Golland, 2015a). Other works studied the individual vs. shared characteristics of motion (Hart, Noy, Feniger-Schaal, Mayo, & Alon, 2014; Noy, Alon, & Friedman, 2015b); developed a computerized version of the mirror-game with implications for rehabilitation of social deficits (Zhai, Alderisio, Tsaneva-Atanasova, & Di Bernardo, 2014); used the mirror-game to measure the link between synchrony and improvisation (Gueugnon et al., 2016); used the mirror-game as a socio-motor biomarker for schizophrenia (Słowiński et al., 2017) and autism (Brezis et al., 2017); explored group dynamics during the mirror-game (Himberg, Laroche, Bigé, Buchkowski, & Bachrach, 2018), and used the mirror-game to assess attachment patterns (Feniger-Schaal, Hart, Lotan, Koren-Karie, & Noy, 2018).

The proposed intervention, even though it has never been tested in older adults, appears to be well suited to this population. The mirror-game

involves several unique characteristics, including interpersonal synchrony, imitation, and playfulness. The combination of those components in one activity – the mirror-game – might contribute to positive outcomes in prosocial and cognitive domains for older adults, as detailed next. The intense interaction in a dyadic interpersonal synchrony may have a positive effect on older adults' sense of belonging, their experience of being seen, and their sense of being involved with the other (as found in younger adults, Mogan et al., 2017). There are research evidences that imitation, which is at the core of the mirror-game intervention, has a positive impact on cognitive performance in older adults. For example, a pilot study found that the physical exercise of older adults, which involves imitation, improves cognitive performance – memory and attention (Shigematsu, Okura, Nakagaichi, & Nakata, 2014). Furthermore, the scarce literature on playfulness with older adults – as an act that involves creativity, spontaneity, and joy (Yarnal & Qian, 2011) – found it to be associated with well-being and healthy aging (Killick & Allan, 2012; Waldman-levi, Erez, & Katz, 2015).

Finally, recent studies from our research group employed the mirror-game exercise as a warm-up exercise in drama therapy sessions with older adults (Keisari & Palgi, 2017; Keisari, Yaniv, Palgi, & Gesser-Edelsburg, 2018). Some hints on the positive impact of the mirror-game were already experienced in these studies (yet were not the focus of these studies). Following the mirror-game, the participants reported positive experiences. They seemed to be more engaged in the group process and expressed pleasure and joy. The personal experience in these studies led us to initiate the current study.

### **The current study**

The present study is the first to examine the effect of the mirror-game intervention on socio-emotional factors as well as cognitive performance of older adults. We compared the mirror-game to a standard physical activity procedure, common in day-centers for older adults, controlling for coordinated physical motion in a social context. To account for the vast variability of performance in older age, the study has employed a within-

between experimental design, in which each participant took part in both types of interventions. We measured both cognitive performance and subjective assessments (mood and social relatedness) before and after the intervention. Our cognitive measures included both a brief standardized attention test (working memory span and manipulation) and a test of spoken word recognition in noise. Speech perception, especially in noise, is a complex task that involves various cognitive abilities (Ben-David et al., 2011; Benichov, Cox, Tun, & Wingfield, 2012). Yet unlike standardized cognitive tests, it is a daily task that older adults report is a main challenge in their lives (Pichora-Fuller & Singh, 2006), impeding social interactions (Heinrich et al., 2016a). To overcome possible differences in hearing, a variety of signal-to-noise levels and a within-participant design was used (Ben-David, Vania, & Schneider, 2012). If the brief mirror-game intervention can indeed effect mood and cognitive performance, we can expect to find a significant improvement across measures following the mirror-game, which will not be apparent (or at least not the same extent) following the control physical activity intervention.

## **Method**

### **Participants**

We followed the CONSORT statement (Schulz, Altman, & Moher, 2010) when relevant; including inclusion criteria, recruitment processes, random assignment, sample size, results, etc. Participants were recruited from an adult day center in northern Israel using the following inclusion criteria: 1) a score of 25 or more on the Mini-Mental State Examination (MMSE>24), indicating a normal cognitive level (Woodford & George, 2007); 2) Visual ability high enough to follow other's movement, but we did not exclude participants with limited visual ability to avoid self-selection; 3) hearing level high enough to follow instruction, without removing impaired hearing to avoid self-selection.

Data determining compatibility were retrieved by the adult day center's social worker through records there. Fifty-two members met the study's criteria and were offered to participate in the study.

The research team introduced the study to all of them, of which 39 agreed to participate. Five members failed to complete both experimental sessions and were not included in the final sample.

Thirty-four participants completed the study (26 women, eight men) and received the equivalent of 10 USD for their participation. The mean age was 83.9 years (range = 71–98 years old).

An a-priori power analysis in G\*power (Erdfelder, FAul, Buchner, & Lang, 2009) for a  $2 \times 2$  (repeated measures, within) X2 (between) mixed-model ANOVA assuming a small effect size ( $f = .20$ , a conservative estimate; taken as a third of the power found for response latencies effects with older adults, Tziraki, Berenbaum, Gross, Abikhzer, & Ben-David, 2017) and a medium-high correlation between repeated measures (.75, as the same measures were tested before and after intervention) suggested 30 participants to obtain .96 power; 34 participants were recruited in anticipation of attrition.

### **Procedure**

The study was ethically approved by the IRB of the University of Haifa (No. 203/18).

All participants read and signed an informed consent form to participate in the study and to obtain data from their files in the day center. The study took place in a quiet space at the adult day center and consisted of two sessions, a mirror-game and a control exercise, separated by a week. A random half of the participants were assigned to practice the mirror-game at the first stage and control exercise in the second stage, whereas for the other participants this order was reversed. A randomized list of numbers was generated by Microsoft Excel 2016 software. One researcher assigned each participant to the intervention according to this randomized list. Both sessions commenced with a battery of tests and self-reports before and after each session. The battery of tests was conducted by the researchers in our team and the activities (the mirror-game and the exercise class) were conducted by experimenters that were unfamiliar with the participants. An experimenter was presented throughout each session. Three

experimenters took part in the study, with a different experimenter (randomly assigned) administering the mirror-game and the exercise sessions. All self-reports and tests were administered individually in a quiet room before and after each activity by the researchers. Items were read aloud to participants when this was necessary, and responses were given orally and coded by the researcher. Data were collected during the period of July 17 to August 18, 2018.

### ***The mirror-game session***

The task was administered individually to each participant. Each participant was instructed to produce mirror-like movements together with an experimenter, who was trained and experienced in administering this task in a clinical setting. The session included three rounds, each three minutes long. In all rounds, both the participant and the experimenter sat in front of each other on comfortable chairs, about 1.5 meters away. In round 1, the participant was asked to generate spontaneous movements, and the experimenter imitated them as if she were a mirror to the participant. In round 2, the participant and experimenter changed roles. In round 3, both the participant and the experimenter moved together, mirroring each other, without a designated leader (for full instructions, see Appendix A, and Figure 1 for examples of the setting).

### ***The exercise (control) session***

This session was designed to control for the possible effects of synchronized movements in the mirror-game session. Participants were randomly divided into pairs. Both participants sat in a row on comfortable chairs with one experimenter sitting between them, in front of a second experimenter who served as an “exercise teacher.” The session was introduced to participants as an exercise class, a procedure they are familiar with from experience in the day center. In a 9-minute session, participants were asked to copy a repetitive set of six hand and head movements, as presented by the facilitator (for full instructions and protocol see Appendix B).





**Figure 1.** Examples of the mirror-game. The participant and the experimenter both sitting on chairs facing each other while imitating each other's movements. The participants gave their full consent to the publication of their photo.

## Measures

### Self-report questionnaires and neuropsychological measures

As mentioned above, previous experience with practicing the mirror-game with older adults (Keisari & Palgi, 2017; Keisari et al., 2018) and the existing literature on manipulated synchrony (Mogan et al., 2017) led to the use of affective and social indices, as well as a gauge of attentional functions. Due to the short duration of the intervention, only brief measurements were used to assess the study indices.

**Self-report measures used in the study.** Background characteristics included age, gender, family status, years of education, religiosity level (dichotomized into religious and non-religious), and place of birth.

*Affect* was measured using the *Positive and Negative Experience* (SPANE) (Diener et al., 2010). We used this questionnaire to assess the effect of the intervention on mood. This is a brief 12-item self-report questionnaire on the current experience, with six items assessing positive feelings and six assessing negative feelings (Diener et al., 2010). Ratings on negative and positive feelings were re-coded, such that an increase in ratings indicates an increase in positive experience and a decrease in negative experience. The Cronbach's coefficient for *positive feelings* was  $\alpha = 0.86$  and for *negative feelings*  $\alpha = 0.81$ .

*Satisfaction with social relationships* was measured using the revised version of the UCLA Loneliness Scale (Russell, Peplau, & Cutrona,

1980). This self-report inventory includes 20 statements, scored on a scale ranging from 1 (never) to 4 (often). In this study, we used 10 items measuring *satisfaction with social relationships* to assess the effect of the intervention on the way participants perceived their social relationships. The Cronbach's coefficient in this study was  $\alpha = 0.73$ .

*Perceived responsiveness* was measure using the 4-item *Perceived Partner Responsiveness Subscale* (PPRS; Reis, Maniaci, Caprariello, Eastwick, & Finkel, 2011). This questionnaire examined the participants' subjective assessment of the experimenter's responsiveness to them. We requested participants to reflect on the experience they had just had with the experimenter (during the session). The PPRS was used in previous studies to assess the development of a relationship specifically after interpersonal synchrony manipulation between unfamiliar partners (Sharon-David et al., 2018). The Cronbach's coefficient in this study was  $\alpha = 0.80$ .

### Attentional function

The two tools used to gauge attentional functions were: 1) a basic cognitive assessment test, and 2) a spoken word in noise detection test. The former provides a standardized measure of cognitive performance, while the latter mimics a real-life task of speech perception in adverse conditions.

The three attention subscales of the *Montreal Cognitive Assessment* (MoCA, 2019; Nasreddine et al., 2005) were used to assess attention function by three subscales: a) digit span, assessing working memory capacity; b) letter A, a target detection task,

assessing inhibition and detection; c) serial 7, a serial subtraction task, assessing manipulation of working memory (for a full manual, see <https://www.mocat.org/paper/>). Subscales of the MoCA were chosen, as it is one of the most commonly used tests to gauge basic cognitive performance in aging, and is known for its reliability and validity (Nasreddine et al., 2019). It was also chosen because of its feasibility, as it is a brief test that can be simply administered and coded. The three subscales were chosen as they are viewed as tapping the domain of “attention, concentration, and working memory” with a high construct validity (see correlation coefficients in Freitas, Simoes, Marôco, Alves, & Santana, 2012). The attention subscales were taken from two versions of the test, such that a different version was presented before and after the experimental activity (versions 7.2 and 7.3). The allocation was fully counterbalanced across participants.

*Spoken word detection in noise* (for the effects of sound sharing in aging see, Ben-David et al., 2011 and on spoken Hebrew, see; Hadar, Skrzypek, Wingfield, & Ben-David, 2016). Two sets of three disyllabic Hebrew words were used (see Appendix C; words were emotionally neutral, see Ben-David, Moral, Namasivayam, Erel, & van Lieshout, 2016): a target word, an onset sharing word, and an offset sharing word. A different set of stimuli was presented before and after each experimental activity, with set order counterbalanced across conditions and participants. Stimuli were mixed with speech spectrum noise (taken from Nitsan, Wingfield, Lavie, & Ben-David, 2019) in five speech-to-noise ratios (SNR), which ranged in difficulty:  $-6$  dB (most difficult, with the speech presented at 6 dB below the noise),  $-4$  dB,  $-2$  dB, 0 dB,  $+2$  dB (easiest, with the speech presented at 2 dB above the noise). Each session consisted of a random presentation of 40 trials: 20 trials included the target words (four repetitions of each SNR), and 20 trials included the competitor words (two repetitions of each SNR of each competitor).

The session began with instructions. Participants were then presented with a spoken word and asked to detect the presence of the target word by pressing the YES button or indicate its absence (the presence of a competitor word) by pressing the NO button. No feedback was provided. This test yielded two measurements: *accuracy* (the number of correct yes and no responses divided by the total number of trials)

and *response latencies* (the average time from word onset to recorded keypress response), recorded separately for correct and incorrect responses. These measures were recorded by designated software. The order of the stimuli, as related to their identity (target or competitor) and the SNR condition, was fully randomized.

### Data analysis

All data were submitted to a mixed-model repeated-measures ANOVA, using SPSS (v23), with intervention type (mirror-game vs. exercise) and intervention effect (before/after the intervention) as within-participant variables, and order of the interventions (mirror-game at the first/second session) as a between-participant variable. The order of intervention did not yield a significant main effect or a significant interaction with any of the main tested factors, in all of the following analyses, and thus will not be further discussed. The dependent variables are specified in each test;  $p$  value  $\leq .05$  was taken to indicate the significance of tests; partial eta squared ( $\eta_p^2$ ) was used as the measure for effect size in all statistically significant tests.

In a preliminary stage, all data were tested to ensure that assumptions for the use of mixed-model ANOVA were met for all of the tested data: homogeneity of variance was set using Box's  $M \leq 9.0$ ,  $F < 1.45$ ,  $p \geq .23$ ; normality of residual distribution was established by ensuring that residual skewness (and/or Kurtosis) was less than 2.5 standard deviations (Kim, 2013); absence of influential values was set by Cook's  $D < .35$  (Cook, 1977). To reach this level of Cook's  $D$ , one participant was removed from the analysis of satisfaction with social relationship score and another one from the analysis of PPRS, as their Cook's  $D$  score suggested possible deviation. Negative experience scores were not found to follow a normal distribution, even after an attempt to remove possible influential data, and these scores were analyzed using non-parametric tests.

## Results

### Attentional functions

The mirror-game and the exercise class were found to have a different effect on the MoCA

subscales (a significant interaction of intervention type and intervention effect),  $F(1,30) = 6.0$ ,  $p = .02$ ,  $\eta_p^2 = .17$ . While the mirror-game intervention led to a significant improvement in the attention measure,  $F(1,30) = 4.85$ ,  $p = .03$ ,  $\eta_p^2 = .14$ , the exercise intervention did not,  $F(1,30) = 1.2$ ,  $p = .27$ . Note, as aforementioned, three tests were included in the MoCA attention subscale. The analysis shows that the type of test did not affect the interaction significantly or any of the other effects,  $F < 0.7$ ,  $p > .5$ . Thus, the three tests can be grouped into one measure (for further information, see Table 1 and Figure 2). In sum, results indicate that playing the mirror-game significantly improved attentional performance as measured by the attentional MoCA subscales. However, the exercise intervention did not lead to any significant change in performance.

### Spoken word detection in noise

#### Accuracy analysis

Accuracy was found to improve following both types of intervention (a significant main effect for intervention),  $F(1,30) = 18.88$ ,  $p = .001$ ,  $\eta_p^2 = .40$ . This finding may reflect a practice effect, as accuracy did not improve to a significantly different extent following the mirror game and the exercise session,  $F(1,30) = 1.03$ ,  $p = .32$  (no significant interaction of intervention effect and intervention type). None of the other main effects or interactions were significant.

#### Latency analysis (response time)

Responses faster than 150 ms were discarded (indicating responses initiated before the stimulus onset; see Ben-David, Eidels, & Donkin, 2014). Following this, and as some participants performed at 100% accuracy, we conducted an analysis of latency separately for correct and incorrect responses.

For correct responses, latencies were significantly improved by the mirror-game intervention,  $F(1,31) = 11.4$ ,  $p = .002$ ,  $\eta_p^2 = .27$ , but not by the exercise intervention,  $F(1,30) = .19$ ,  $p = .67$ , as qualified by a significant interaction of intervention type and intervention effect,  $F(1,29) = 5.7$ ,  $p = .024$ ,  $\eta_p^2 = .17$ . For incorrect responses, none of the main effects and the interactions were found to be significant,  $F < 1$  for all (for further information, see Table 1 and Figure 2). In sum, playing the mirror-game improved response times for correct identification of spoken words in noise, but the exercise game did not lead to such a change in performance.

#### Satisfaction with social relationships

It appears that both interventions elevated self-reports on social relationships  $F(1,31) = 11.4$ ,  $p = .002$ ,  $\eta_p^2 = .27$ , to a non-significantly different extent,  $F(1,31) = .60$ ,  $p = .45$  (no significant interaction of intervention effect and intervention type). None of the other main effects or interactions were significant.

**Table 1.** Means and standard deviations (in parenthesis) for the different measures collected before and after the experimental and the control condition, alongside the effects indicating whether the mirror-game intervention had a larger effect than the control condition or not.

	Mirror game		Control condition		Time × type-of-intervention interaction
	Before M (SD)	After M (SD)	Before M (SD)	After M (SD)	
MoCA attention sub-scales	1.21 (.12)	1.44 (.11)	1.27 (.12)	1.19 (.11)	$F(1,31) = 7.2$ , $p = .01$ , $\eta^2 = .19$
Accuracy of answers in spoken word detection in noise	70% (4)	78% (3)	71% (3)	75% (3)	$F(1,30) = 1.03$ $p = .32$
Latency (ms) for correct responses in spoken word detection in noise	436 (16)	395 (18)	445 (16)	459 (16)	$F(1,29) = 5.7$ , $p = .024$ , $\eta^2 = .17$
Satisfaction with social relationship	3.46 (.07)	3.60 (.06)	3.56 (.07)	3.66 (.09)	$F(1,31) = .60$ , $p = .45$
Positive experience	4.08 (.13)	4.54 (.09)	4.12 (.14)	4.11 (.17)	$F(1,31) = 11.40$ , $p = .002$ , $\eta^2 = .27$
Perceived partner responsiveness		5.97 (.17)		4.22(.27)	$F(1,31) = 49.4$ , $p < .001$ , $\eta^2 = .62$

The average of the three MoCA (2019) subscales have a range of 0 (minimal) to 3 (maximal performance). Spoken word detection has an accuracy range of 50% (chance level) to 100%. Satisfaction with social relationships (Russell et al., 1980) – a range of 1 (minimal) to 4 (maximal). Positive and negative experience (Diener et al., 2010) – note the scores reflect an average across positive and negative (reverse scale) experiences, with a range of 1 (negative) to 5 (positive). Perceived partner responsiveness (Reis et al., 2011) – a range of 1 (minimal) to 7 (maximal).



### Positive and negative experience

Positive: The mirror-game and the exercise class were found to have a different effect on positive experience (a significant interaction of intervention type and intervention effect),  $F(1,31) = 11.40$ ,  $p = .002$ ,  $\eta_p^2 = .27$ . While the mirror-game intervention lead to a significant improvement,  $F(1,31) = 23.7$ ,  $p < .001$ ,  $\eta_p^2 = .43$ , the exercise intervention did not,  $F(1,32) = .02$ ,  $p = .88$  (for further information, see Table 1 and Figure 2).

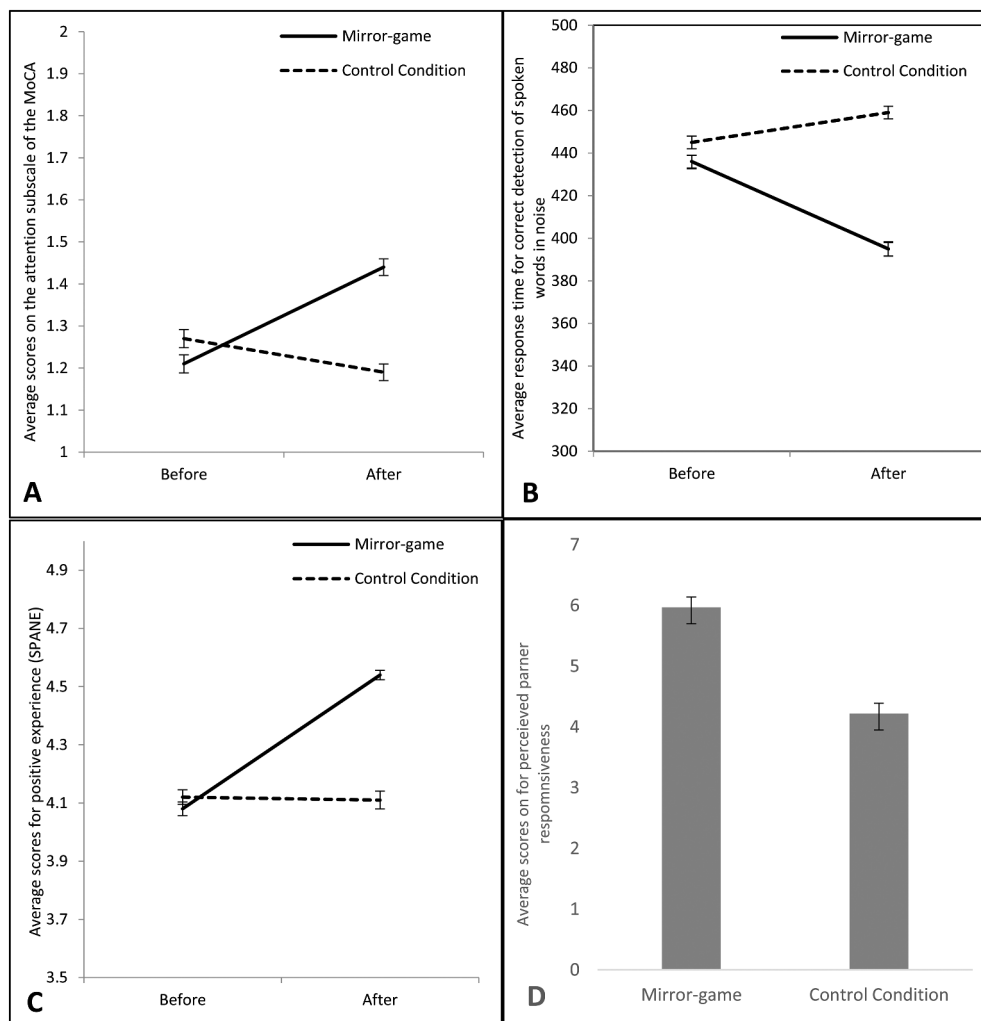
Negative: A non-parametric test was conducted – the Wilcoxon signed ranked test for related samples. The mirror game was found to significantly reduce negative experience,  $p < .001$ ; the exercise did not,  $p = .59$ .

In sum, the mirror-game was found to significantly increase positive experience and reduce

negative experience, but no such changes in experience were noted following the exercise intervention.

### Perceived partner responsiveness

PPS scores were found to be significantly higher following the mirror-game intervention than following the exercise intervention,  $F(1,31) = 49.4$ ,  $p < .001$ ,  $\eta_p^2 = .62$ . (see Figure 2). In separate analyses, it was verified that the mirror-game specific effect could be related to the intervention itself and not merely to the individual experimenter, as the effect was replicated for all experimenters: for experimenter 1, 6.0 vs 4.2,  $t(17) = 2.5$ ,  $p = .024$ ; experimenter 2, 5.8 vs 4.3,  $t(23) = 2.6$ ,  $p = .016$ ; experimenter 3, 5.7 vs. 4.2,  $t(18) = 2.46$ ,  $p = .025$ .



**Figure 2.** Comparing mirror game and control condition on outcome measures. Averages before and after the mirror-game and control condition, for Panel A – scores on the attention subscale of the MoCA, Panel B – response times for correct detection of spoken words in noise, Panel C – scores on a self-report for positive experience, Panel D – presents average scores on a self-report for perceived partner responsiveness (Perceived Partner Responsiveness, PPRS), as reported immediately after the mirror-game and control condition. In all panels, error bars reflect standard errors of the mean.

In sum, it appears that the mirror-game led to higher perceived responsiveness of the experimenter than did the control exercise. This effect was not merely due to a difference between experimenters but appears to be directly related to the type of intervention. These effects were not reduced, even after controlling for the order of the activity (the activity conducted first, mirror-game or exercise class).

## Discussion

The present study aimed to evaluate the effect of a brief mirror-game intervention on immediate socio-emotional ratings and attentional function of community-dwelling older adults. To the best of our knowledge, this study marks the first attempt to examine the effects of a synchrony exercise, specifically a mirror-game exercise, in older adults. The mirror-game is a physical, synchronized interpersonal activity that involves playfulness and creativity. Performance following a 9-minute mirror-game intervention was compared, within participants, to a 9-minute standard exercise class. Our results indicate significantly larger improvement in social, emotional, and attention function after practicing the mirror-game, compared to an exercise class. The broad literature on the effect of physical exercise on the well-being of older adults indicates its positive effect on cognitive, social, and emotional measures (Bherer, Erickson, & Liu-Ambrose, 2013). In this study, both interventions – the mirror-game and the control condition – involve physical activity to a similar extent. However, the results indicate that the mirror-game has a distinct advantage over the exercise class on most of the measures. This may be due to some unique characteristics of the physical activity of the mirror-game.

First and foremost, the mirror-game involves interpersonal movement synchrony. Our results join the growing literature on the subject that stresses the positive effect of interpersonal movement synchrony on social, emotional, and cognitive indices (see, Hove & Risen, 2009; Mogan et al., 2017). In addition, mutual imitation contributes to a sense of embodied empathy, and intensification of the interpersonal encounter (McGarry & Russo,

2011), which may in turn contribute to elevated positive affect and better cognitive functioning.

The mirror-game led to a better positive experience compared to the exercise class. As mentioned, this might be as a result of the interpersonal synchrony which is a central component of the mirror-game, and that was already found to have a positive influence on affect (Fessler & Holbrook, 2014). Another quality of the mirror-game which may contribute to the results is playfulness. This debatable construct refers to the ability to act with a sense of creativity, spontaneity, and joy (Yarnal & Qian, 2011). The mirror-game, unlike the exercise class, involves the creation of a spontaneous, free movement of self-expression that many times results in moments of shared positive affect and joy. The scarce literature on playfulness in old age points to the potential positive effect of playfulness on healthy aging (Swinnen & de Medeiros, 2018; Waldman-levi et al., 2015; Yarnal & Qian, 2011). We carefully assume that the sense of playfulness that accompanies the mirror-game contributes to the positive effect on our outcome measures.

The results indicate that a sense of satisfaction with social relationships was improved after both the mirror-game and the exercise session. We assume this occurred due to the fact that both activities involved physical movements in a social context (with other people) that affects the participants' social experience. On the other hand, perceived partner responsiveness was affected by the type of intervention, with higher scores after the mirror-game, than after the exercise class. In other words, the mirror-game affects the participants' perception of their partner (the experimenter), and s/he is perceived as someone who better understands, validates, and cares for them (Reis, Clark, & Holmes, 2004). Perceived partner responsiveness is a central aspect of satisfying relationships (Lemay, Clark, & Feeney, 2007). Therefore, the ability to improve the way people perceive the members of their own community may positively affect their social relationships in the community. Considering the loneliness and social losses common to late life, a positive experience with the other has special value in promoting a positive view of the self and others (Baltes & Carstensen, 1996; Johnson & Mutchler, 2014).

The mirror-game brief intervention was also found to have substantial effects on the attentional functions. Nine minutes of playing the mirror-game increased performance in the attention subscale of the MoCA. It also improved performance on a spoken word in noise task, with faster correct identifications of the target word. No significant changes in cognitive performance were recorded following the exercise class. We assume that this impact results from some unique characteristics of the mirror-game as detailed below. The mirror-game entails some cognitive demands related to the imitation of ongoing changing movements. These demands include inhibitions of external stimuli together with attention and concentration while following an unpredictable stimulus. Together, they represent central cognitive abilities in daily activities (Ben-David, Malkin, & Erel, 2018) and are considered as a part of executive functions (Baddeley, 1996). In addition, the intense dyadic interpersonal synchrony might also positively influence the attentional function, as a result of the need to maintain intense social connectedness with the other (Hove & Risen, 2009; Miles et al., 2010; Rennung & Göritz, 2016).

Improved efficiency of spoken word identification in noise, following the mirror-game, is an indication of a “far transfer of learning” – practicing synchronicity in motion with another person led to improved auditory performance (a skill far from the context of the intervention) and not only improved perception of the other (closer context). This far transfer of learning indicates that the underlying processes activated by the mirror-game may be more fundamental than previously assumed. This result also has potential applied implications, as difficulties in speech perception present one of the major difficulties that older adults experience (CHABA, 1988). These difficulties have long-term implications, such as loneliness, reduced physical and social activity, depression, and even reduced life expectancy (for reviews, see Heinrich, Henshaw, & Ferguson, 2016b; Lin & Ferrucci, 2012). They also have short-term immediate implications: difficulties in speech processing pose a barrier to speech-moderated interventions, such as therapy, medical services, and even simple advice from a friend (for a discussion, Leshem, van Lieshout, Ben-David, & Ben-David, 2019). Thus,

our data showcase a possible short and simple intervention that may directly assist older clients to better understand spoken messages.

### **Limitations**

The study has several limitations that may influence the results. In this study, we tried to compare the mirror-game to a common physical activity in the adult day center routine, the exercise session (which is usually conducted with people sitting in a row, next to each other).

The mirror-game is usually conducted, in this study as well, as a one-on-one movement interaction, with people facing each other. This may have contributed both to the significant difference in the perception of the partner and to the cognitive measures, as one-on-one activity demands different attention and concentration. Therefore, it may be claimed that one of the sources of differences in the impact of the mirror-game as compared to the exercise session lay in this different setting. This claim needs to be further examined in future studies that will isolate the specific feature of the setting.

Interpersonal movement synchrony may have contributed to the effect of the mirror-game. However, the exercise class may have included some movement synchrony as well, since the participants are instructed to follow the instructor’s movement. Still, the mirror-game had a clear advantage over the exercise activity. Future studies, therefore, are needed in order to determine the specific role of movement synchrony in the effect of the mirror-game.

Another important question that has remained unanswered involves the lasting effect of the results. In the present study, we measured the effect of both conditions right after the short intervention. We do not know about the lasting effect of the intervention, and how often it might need to be conducted to produce prolonged results. Following the study results, future research should also examine a routine practice of the mirror-game throughout a few weeks and its possible effect on varied indices including depression. Furthermore, the inclusion criteria took into consideration only the reported score

of the Mini-Mental State Examination (MMSE>24). This study did not take into consideration the geriatric depression score, even though depression might also influence the intervention effect due to its association to cognitive impairment (e.g., Weisenbach, Boore, & Kales, 2012). Future research should consider the evaluation of geriatric depression as an inclusion criterion for the study. Note, in order to increase the representativeness of the participant group, we did not exclude older adults based on clinical measures of hearing and vision. Since sensory factors can affect cognitive performance (Ben-David & Schneider, 2009, 2010) and speech perception (Ben-David, Gal-Rosenblum, van Lieshout, & Shakuf, 2019), future studies should continue to test their possible interactions with the effects of the mirror game. Finally, as this was a pioneer study in the field, one should replicate the results with a different group of older adults, increasing the number of participants to support the reliability and validity of the manipulation.

### Clinical implications

The mirror-game is a novel intervention, with potential benefits of social-emotional and cognitive functioning, which can be easily implemented into the daily routine care of older adults.

### Acknowledgments

We are grateful to BEIT AVRAHAM, The Sephardic Home for the Aged, and its adult day center for their generosity and collaboration. We thank all the research assistances that took part in the study. Finally, we thank the faculty of social welfare and social science at the University of Haifa, for supporting our study.

### Disclosure statement

The authors declare that there is no conflict of interest.

### Funding

This work was supported by the The Faculty Social Welfare & Health Sciences, the University of Haifa, Israel [The Faculty Social Welfare & Health Sciences Grant].

### ORCID

Shoshi Keisari PhD  <http://orcid.org/0000-0003-1988-7601>

Yuval Palgi PhD  <http://orcid.org/0000-0002-8675-5513>

Anat Gesser-Edelsburg PhD  <http://orcid.org/0000-0003-4467-8799>

Boaz Ben-David PhD  <http://orcid.org/0000-0002-0392-962X>

### References

- Baddeley, A. (1996). The fractionation of working memory. *Proceedings of the National Academy of Sciences of the United States of America*, 93(24), 13468–13472. doi:10.1073/pnas.93.24.13468
- Baimel, A., Severson, R. L., Baron, A. S., & Birch, S. A. (2015). Enhancing “theory of mind” through behavioral synchrony. *Frontiers in Psychology*, 6, 870. doi:10.3389/fpsyg.2015.00870
- Baltes, M. M., & Carstensen, L. L. (1996). The process of successful ageing. *Ageing and Society*, 16(4), 397–422. doi:10.1017/S0144686X00003603
- Ben-David, B. M., Chambers, C. G., Daneman, M., Pichora-Fuller, M. K., Reingold, E. M., & Schneider, B. A. (2011). Effects of aging and noise on real-time spoken word recognition: Evidence from eye movements. *Journal of Speech, Language, and Hearing Research*, 54(1), 243–262. doi:10.1044/1092-4388(2010/09-0233)
- Ben-David, B. M., Eidels, A., & Donkin, C. (2014). Effects of aging and distractors on detection of redundant visual targets and capacity: Do older adults integrate visual targets differently than younger adults? *PLoS One*, 9(12). doi:10.1371/journal.pone.0113551
- Ben-David, B. M., Gal-Rosenblum, S., van Lieshout, P. H., & Shakuf, V. (2019). Age-related differences in the perception of emotion in spoken language: The relative roles of prosody and semantics. *Journal of Speech, Language, and Hearing Research*, 62(4S), 1188–1202. doi:10.1044/2018\_JSLHR-H-ASCC7-18-0166
- Ben-David, B. M., Malkin, G., & Erel, H. (2018). Ageism and neuropsychological tests. In C. Ayalon & C. Tesch-Römer (Eds.), *Contemporary perspectives on ageism* (pp. 277–297). Cham: Springer Open.
- Ben-David, B. M., Moral, M. I., Namasivayam, A. K., Erel, H., & van Lieshout, P. H. (2016). Linguistic and emotional-valence characteristics of reading passages for clinical use and research. *Journal of Fluency Disorders*, 49, 1–12. doi:10.1016/j.jfludis.2016.06.003
- Ben-David, B. M., & Schneider, B. A. (2009). A sensory origin for color-word Stroop effects in aging: A meta-analysis. *Aging, Neuropsychology, and Cognition*, 16(5), 505–534. doi:10.1080/13825580902855862
- Ben-David, B. M., & Schneider, B. A. (2010). A sensory origin for color-word Stroop effects in aging: Simulating age-related changes in color-vision mimics age-related changes in Stroop. *Aging, Neuropsychology, and*



- Cognition*, 17(6), 730–746. doi:10.1080/13825585.2010.510553
- Ben-David, B. M., Vania, Y. Y., & Schneider, B. A. (2012). Does it take older adults longer than younger adults to perceptually segregate a speech target from a background masker? *Hearing Research*, 290(1–2), 55–63. doi:10.1016/j.heares.2012.04.022
- Benichov, J., Cox, L. C., Tun, P. A., & Wingfield, A. (2012). Word recognition within a linguistic context: Effects of age, hearing acuity, verbal ability, and cognitive function. *Ear and Hearing*, 33(2), 250–256. doi:10.1097/AUD.0b013e31822f680f
- Bherer, L., Erickson, K. I., & Liu-Ambrose, T. (2013). A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. *Journal of Aging Research*, 1–8. doi:10.1155/2013/657508
- Boal, A. (2013). *The rainbow of desire: The Boal method of theatre and therapy*. Abingdon: Routledge.
- Brezis, R.-S., Noy, L., Alony, T., Gotlieb, R., Cohen, R., Golland, Y., & Levit-Binnun, N. (2017). Patterns of joint improvisation in adults with autism spectrum disorder. *Frontiers in Psychology*, 8, 1790. doi:10.3389/fpsyg.2017.01790
- CHABA. (1988). Speech understanding and aging. *Committee on Hearing and Bioacoustics and Biomechanics, Journal of the Acoustical Society of America*, 83, 859–895.
- Cook, R. D. (1977). Detection of influential observation in linear regression. *Technometrics*, 19(1), 15–18.
- Diener, E., & Chan, M. Y. (2011). Happy people live longer: Subjective well-being contributes to health and longevity. *Applied Psychology: Health and Well-Being*, 3(1), 1–43.
- Diener, E., Wirtz, D., Tov, W., Kim-Prieto, C., Choi, D. W., Oishi, S., & Biswas-Diener, R. (2010). New well-being measures: Short scales to assess flourishing and positive and negative feelings. *Social Indicators Research*, 97(2), 143–156. doi:10.1007/s11205-009-9493-y
- Erdfelder, E., FAul, F., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149–1160. doi:10.3758/BRM.41.4.1149
- Feniger-Schaal, R., Hart, Y., Lotan, N., Koren-Karie, N., & Noy, L. (2018). The body speaks: Using the mirror game to link attachment and non-verbal behavior. *Frontiers in Psychology*, 9, 1560. doi:10.3389/fpsyg.2018.01560
- Fessler, D. M., & Holbrook, C. (2014). Marching into battle: Synchronized walking diminishes the conceptualized formidability of an antagonist in men. *Biology Letters*, 10(8), 20140592. doi:10.1098/rsbl.2014.0592
- Freitas, S., Simoes, M. R., Marôco, J., Alves, L., & Santana, I. (2012). Construct validity of the montreal cognitive assessment (MoCA). *Journal of the International Neuropsychological Society*, 18(2), 242–250. doi:10.1017/S1355617711001573
- Gueugnon, M., Salesse, R. N., Coste, A., Zhao, Z., Bardy, B. G., & Marin, L. (2016). The acquisition of socio-motor improvisation in the mirror game. *Human Movement Science*, 46, 117–128. doi:10.1016/j.humov.2015.12.005
- Hadar, B., Skrzypek, J. E., Wingfield, A., & Ben-David, B. M. (2016). Working memory load affects processing time in spoken word recognition: Evidence from eye-movements. *Frontiers in Neuroscience*, 10, 221. doi:10.3389/fnins.2016.00221
- Hart, Y., Noy, L., Feniger-Schaal, R., Mayo, A. E., & Alon, U. (2014). Individuality and togetherness in joint improvised motion. *PLoS ONE*, 9(2). doi:10.1371/journal.pone.0087213
- Haslam, C., Cruwys, T., & Haslam, S. A. (2014). “The we’s have it”: Evidence for the distinctive benefits of group engagement in enhancing cognitive health in aging. *Social Science & Medicine*, 120, 57–66. doi:10.1016/j.socscimed.2014.08.037
- Heinrich, A., Gagne, J. P., Viljanen, A., Levy, D. A., Ben-David, B. M., & Schneider, B. A. (2016a). Effective communication as a fundamental aspect of active aging and well-being: Paying attention to the challenges older adults face in noisy environments. *Social Inquiry into Well-Being*, 2(1), 51–69. doi:10.13165/SIIW-16-2-1-05
- Heinrich, A., Henshaw, H., & Ferguson, M. A. (2016b). Only behavioral but not self-report measures of speech perception correlate with cognitive abilities. *Frontiers in Psychology*, 7, 576. doi:10.3389/fpsyg.2016.00576
- Himberg, T., Laroche, J., Bigé, R., Buchkowski, M., & Bachrach, A. (2018). Coordinated interpersonal behaviour in collective dance improvisation: The aesthetics of kinaesthetic togetherness. *Behavioral Sciences*, 8(2), 1–26. doi:10.3390/bs8020023
- Hove, M. J., & Risen, J. L. (2009). It’s all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition*, 27(6), 949–960. doi:10.1521/soco.2009.27.6.949
- Huppert, F. A. (2009). Psychological well-being: Evidence regarding its causes and consequences. *Applied Psychology: Health and Well-Being*, 1(2), 137–164. doi:10.1111/j.1758-0854.2009.01008.x
- Johnson, K. J., & Mutchler, J. E. (2014). The emergence of a positive gerontology: From disengagement to social involvement. *Gerontologist*, 54(1), 93–100. doi:10.1093/geront/gnt099
- Julien, D., Brault, M., Chartrand, É., & Bégin, J. (2000). Immediacy behaviours and synchrony in satisfied and dissatisfied couples. *Canadian Journal of Behavioural Science*, 32(2), 84–90. doi:10.1037/h0087103
- Keisari, S., & Palgi, Y. (2017). Life-crossroads on stage: Integrating life review and drama therapy for older adults. *Aging and Mental Health*, 21(10), 1079–1089. doi:10.1080/13607863.2016.1199012
- Keisari, S., Yaniv, D., Palgi, Y., & Gesser-Edelsburg, A. (2018). Conducting playback theatre with older adults: A therapist’s perspective. *The Arts in Psychotherapy*, 60, 72–81. doi:10.1016/j.aip.2018.07.002
- Killick, J., & Allan, K. (2012). *Playfulness and dementia: A practice guide*. London: Jessica Kingsley.
- Kim, H. Y. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, 38(1), 52–54. doi:10.5395/rde.2013.38.1.52

- Krueger, K. R., Wilson, R. S., Kamenetsky, J. M., Barnes, L. L., Bienias, J. L., & Bennett, D. A. (2009). Social engagement and cognitive function in old age. *Experimental Aging Research*, 35(1), 45–60. doi:10.1080/03610730802545028
- Lemay, E. P., Clark, M. S., & Feeney, B. C. (2007). Projection of responsiveness to needs and construction of satisfying communal relationships. *Journal of Personality and Social Psychology*, 92(5), 834–853. doi:10.1037/0022-3514.92.5.834
- Leshem, R., van Lieshout, P. H. H. M., Ben-David, S., & Ben-David, B. M. (2019). Does emotion matter? The role of alexithymia in violent recidivism: A systematic literature review. *Criminal Behaviour and Mental Health*, 29(2), 94–110. doi:10.1002/cbm.2110
- Lin, F. R., & Ferrucci, L. (2012). Hearing loss and falls among older adults in the United States. *Archives of Internal Medicine*, 172(4), 369–371. doi:10.1001/archinternmed.2011.728
- Livingston, G., Sommerlad, A., Orgeta, V., Costafreda, S. G., Huntley, J., Ames, D., ... Cooper, C. (2017). Dementia prevention, intervention, and care. *The Lancet*, 390(10113), 2673–2734. doi:10.1016/S0140-6736(17)31363-6
- McGarry, L. M., & Russo, F. A. (2011). Mirroring in dance/movement therapy: Potential mechanisms behind empathy enhancement. *Arts in Psychotherapy*, 38(3), 178–184. doi:10.1016/j.aip.2011.04.005
- Miles, L. K., Nind, L. K., Henderson, Z., & Macrae, C. N. (2010). Moving memories: Behavioral synchrony and memory for self and others. *Journal of Experimental Social Psychology*, 46(2), 457–460. doi:10.1016/j.jesp.2009.12.006
- MoCA. (2019). *Montreal cognitive assessment*. Retrieved from <https://www.mocatest.org/>
- Mogan, R., Fischer, R., & Bulbulia, J. A. (2017). To be in synchrony or not? A meta-analysis of synchrony's effects on behavior, perception, cognition and affect. *Journal of Experimental Social Psychology*, 72, 13–20. doi:10.1016/j.jesp.2017.03.009
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., & Chertkow, H. (2005). The Montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53(4), 695–699. doi:10.1111/j.1532-5415.2005.53221.x
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., ... Chertkow, H. (2019). “The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment”: Corrigendum. *Journal of the American Geriatrics Society*, 67(9), 1991. doi:10.1111/jgs.15925
- Nitsan, G., Wingfield, A., Lavie, L., & Ben-David, B. M. (2019). Differences in working memory capacity affect online spoken word recognition: Evidence from eye movements. *Trends in Hearing*, 23, 2331216519839624. doi:10.1177/2331216519839624
- Noy, L., Alon, U., & Friedman, J. (2015b). Corrective jitter motion shows similar individual frequencies for the arm and the finger. *Experimental Brain Research*, 233(4), 1307–1320. doi:10.1007/s00221-015-4204-1
- Noy, L., Dekel, E., & Alon, U. (2011). The mirror game as a paradigm for studying the dynamics of two people improvising motion together. *Proceedings of the National Academy of Sciences of the United States of America*, 108(52), 20947–20952. doi:10.1073/pnas.1108155108
- Noy, L., Levit-Binun, N., & Golland, Y. (2015a). Being in the zone: Physiological markers of togetherness in joint improvisation. *Frontiers in Human Neuroscience*, 9, 1–14. doi:10.3389/fnhum.2015.00187
- Pichora-Fuller, M. K., & Singh, G. (2006). Effects of age on auditory and cognitive processing: Implications for hearing aid fitting and audiologic rehabilitation. *Trends in Amplification*, 10(1), 29–59. doi:10.1177/108471380601000103
- Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PLoS One*, 8(8). doi:10.1371/journal.pone.0071182
- Reis, H., Clark, M., & Holmes, J. (2004). Perceived partner responsiveness as an organizing construct in the study of intimacy and closeness. In D. J. Mashek & A. Aron (Eds.), *Handbook of closeness and intimacy* (pp. 211–236). Hillsdale, N.J.: Lawrence Erlbaum Associates Publishers.
- Reis, H. T., Maniaci, M. R., Caprariello, P. A., Eastwick, P. W., & Finkel, E. J. (2011). In live interaction, does familiarity promote attraction or contempt? Reply to Norton, Frost, and Ariely (2011). *Journal of Personality and Social Psychology*, 101, 575–578. doi:10.1037/a0023471
- Rennung, M., & Göritz, A. S. (2016). Prosocial consequences of interpersonal synchrony. *Zeitschrift für Psychologie*, 224, 168–189. doi:10.1027/2151-2604/A000252
- Russell, D., Peplau, L. A., & Cutrona, C. E. (1980). The revised UCLA loneliness scale: Concurrent and discriminant validity evidence. *Journal of Personality and Social Psychology*, 39(2), 472–480. doi:10.1037/0022-3514.39.3.472
- Schechner, R. (1994). *Environmental theater*. New York, NY: Applause Theatre and Cinema Books.
- Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. *BMJ*, 340, c332. doi:10.1136/bmj.c332
- Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: Bodies and minds moving together. *Trends in Cognitive Sciences*, 10(2), 70–76. doi:10.1016/j.tics.2005.12.009
- Sharon-David, H., Mizrahi, M., Rinott, M., Golland, Y., & Birnbaum, G. E. (2018). Being on the same wavelength: Behavioral synchrony between partners and its influence on the experience of intimacy. *Journal of Social and Personal Relationships*, 36(10), 2983–3008. doi:10.1177/0265407518809478
- Shigematsu, R., Okura, T., Nakagaichi, M., & Nakata, Y. (2014). Effects of exercise program requiring attention, memory and imitation on cognitive function in elderly persons: A non-randomized pilot study. *Journal of Gerontology and Geriatric Research*, 3(2). doi:10.4172/2167-7182.1000147
- Słowiński, P., Alderisio, F., Zhai, C., Shen, Y., Tino, P., Bortolon, C., ... Tsaneva-Atanasova, K. (2017). Unravelling socio-motor biomarkers in schizophrenia. *Npj Schizophrenia*, 3(1). doi:10.1038/s41537-016-0009-x

- Swinnen, A., & de Medeiros, K. (2018). "Play" and people living with dementia: A humanities-based inquiry of TimeSlips and the Alzheimer's poetry project. *The Gerontologist*, 58(2), 261–269. doi:10.1093/geront/gnw196
- Tziraki, C., Berenbaum, R., Gross, D., Abikhzer, J., & Ben-David, B. M. (2017). Designing serious computer games for people with moderate and advanced dementia: Interdisciplinary theory-driven pilot study. *JMIR Serious Games*, 5(3), e16. doi:10.2196/games.6514
- Van Baaren, R. B., Holland, R. W., Kawakami, K., & Van Knippenberg, A. (2004). Mimicry and prosocial behavior. *Psychological Science*, 15(1), 71–74. doi:10.1111/j.0963-7214.2004.01501012.x
- Vicaria, I. M., & Dickens, L. (2016). Meta-analyses of the intra- and interpersonal outcomes of interpersonal coordination. *Journal of Nonverbal Behavior*, 40(4), 335–361. doi:10.1007/s10919-016-0238-8
- Waldman-levi, A., Erez, A. B., & Katz, N. (2015). Healthy aging is reflected in well-being, participation, playfulness, and cognitive-emotional functioning. *American Journal of Play*, 4(1), 52–79. doi:10.12715/har.2015.4.8
- Weisenbach, S. L., Boore, L. A., & Kales, H. C. (2012). Depression and cognitive impairment in older adults. *Current Psychiatry Reports*, 14(4), 280–288. doi:10.1007/s11920-012-0278-7
- Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, 20(1), 1–5. doi:10.1111/j.1467-9280.2008.02253x
- Woodford, H. J., & George, J. (2007). Cognitive assessment in the elderly: A review of clinical methods. *QJM*, 100(8), 469–484. doi:10.1093/qjmed/hcm051
- World Health Organization. (2015). *World report on ageing and health*. Retrieved from <https://www.who.int/ageing/events/world-report-2015-launch/en/>
- World Health Organization. (2017). *Mental health of older adults*. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/mental-health-of-older-adults>
- Xu, J., & Roberts, R. E. (2010). The power of positive emotions: It's a matter of life or death—Subjective well-being and longevity over 28 years in a general population. *Health Psychology*, 29(1), 9. doi:10.1037/a0016767
- Yarnal, C., & Qian, X. (2011). Older adult playfulness an innovative construct and measurement for healthy aging research. *American Journal of Play*, 4(11), 52–79.
- Zhai, C., Alderisio, F., Tsaneva-Atanasova, K., & Di Bernardo, M. (2014). A novel cognitive architecture for a human-like virtual player in the mirror game. *Systems, Man and Cybernetics (SMC), 2014 IEEE International Conference*, 754–759. doi: 10.1109/SMC.2014.6974001

## Appendix 1: The mirror-game protocol

<b>Details</b>	This activity takes place with an unfamiliar experimenter and lasts about 9 minutes. The participant is asked to move in synchronized motion with the experimenter in three rounds, each round lasts 3 minutes. In the first round the participant leads the movements, and the experimenter imitates his/her movements. In the second round they switch roles and the experimenter leads the movements and the participant imitates his or her movements and in the last round they both move together without defined roles of a leader or a follower.
<b>Instructions</b>	Hello, my name is ___ and thanks for taking part in this study. We will play together the Mirror Game. This is a game without words. In this game we will create movements together. The aim of the game is simply to produce movement together, like a conversation in movement. This is not a competition. There is no right or wrong. Any movement you make is fine. In the game there are three rounds, each round is three minutes long. In the first round you will be the “leader” so that you will make movements and I will imitate you accurately. After three minutes we will change roles and I will be the leader and you will imitate me. In the third round we will try to make movements together without designated leader. The ring of the clock will give us a sign to move from one to the next round, with no break. It is important that you will be comfortable. Please don't do any movement that cause you pain or make you uncomfortable. The game will take place while sitting. If you feel tired you can rest by slowing down or making movements that demands less effort like moving your head, shoulder, or finger. Any questions? So we begin.
<b>Guidelines</b>	<ol style="list-style-type: none"> <li>1. The experimenter and the participant sit on two chairs facing each other with a meter and half distance.</li> <li>2. The switch between rounds (3 minutes per round) will be done by the clock ring.</li> <li>3. In each round (3 minutes), the participants are encouraged only once, when the game is synchronized with the following words: “This is good”.</li> <li>4. In case the participant play the game incorrectly, the explanation must be repeated and demonstrated again. The goal at this point is to help him/her get synchronized.</li> <li>5. The game will be conducted on a chair so as not to exert additional effort for the participants. Care should be taken to lead movements that do not fatigue particularly, so as not to create resistance. In addition to synchronization in the hands, head movements can be used to allow for rest and avoid over-exertion.</li> </ol>

## Appendix 2: Exercise class

<b>Details</b>	This activity should be conducted by the research team's facilitator in front of a group of three participants: two participants and an experimenter. The activity is similar to the exercise class activity that is conducted during the daily routine of the adult day centre.
<b>Instructions</b>	Hello, my name is ___ and thanks for taking part in this study. We are about to experiment with a nine minutes movement activity, the same as in the exercise class. During the next nine minutes I will demonstrate a movement, and you will have to imitate the movement and repeat it five times, as in an exercise class. This way we will do several movements. We will sit on chairs, and practice common exercise movements of hands, shoulders and the head. This exercise will terminate when the ring bells.
<b>Guidelines</b>	<ol style="list-style-type: none"> <li>1. The facilitator, participants, and experimenter will sit on chairs. The participants and the experimenter sit in line, while the experimenter sits between them. The facilitator sits in front of the group, with a meter and a half distance.</li> <li>2. In the nine minutes activity, participants should be encouraged only twice with the following words: “This is good”.</li> <li>3. The exercise will be conducted on chairs so as not to exert additional effort. Care should be taken to lead movements that do not fatigue particularly, so as not to create resistance. In addition to hand and shoulders movements, head movement can be used to allow for rest and avoid over-exertion.</li> <li>4. Each time the facilitator will demonstrate a movement and the participants will repeat the movement five times.</li> </ol>

## Appendix 3: Speech materials

Speech materials consisted of two sets of three disyllabic Hebrew words: a target word, an onset sharing word, and an offset sharing word. The spoken words were digitally recorded by a native Hebrew-speaking actress in a professional radio studio (IDC radio) using a sampling rate of 4.8 kHz. The root-mean-square average (RMS) intensity was equated across all stimuli. The average target word duration was 783 ms (SD = 118 ms).

	Set 1	Set 2
<b>Target word</b>	KESHER	CHIBUR
<b>Sharing word</b>	KESHET	SIPUR
<b>Sharing word</b>	NESHER	DIBUR