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**Playfulness in online and face-to-face interactions, from adulthood to aging: Physiological, cognitive, and emotional mechanisms and outcomes**

**1.** Scientific background

Engaging in social interactions is vital for human development, from the cradle to the grave. As of birth, infants develop in a continuous interaction with their caregivers. Meaningful social interactions continue to play a pivotal role in mental health and cognitive resilience over the life course [1]. In old age, social connections are known to significantly affect health and well-being [2]. However, for many older individuals, access to social interactions is limited. Social networks shrink due to the increase in morbidity and disability, while difficulties in mobility minimize opportunities [3]. A lack of social interactions, i.e., social isolation, is considered to be a devastating catalyst for decline in mental and physical health, as well as in cognitive functions [4,5]. The COVID-19 social restrictions have exacerbated these challenges, where even older adults with previously active social lives now struggle with increased social isolation and loneliness [6,7]. Accordingly, the maintenance of social interactions for older adults is vital. However, not all interactions are equal: while some can be engaging, meaningful and involving, others are mundane, familiar and have a lesser impact.

Over the past hundred years research has indicated that playful social activities provide rich opportunities for development in all facets of life, and are linked with physical and psychological well-being across the life span [8–10]. Dutch historian Huizinga (1949) suggested that the essential quality of being human is reflected in the term *homo ludens* or “man the player” as opposed to *homo sapiens* (“the knower or the wise”). Play is a crucial activity that supports human beings and animals throughout the life course [11], and enables individuals to acquire and practice complex physical, cognitive and social skills [12]. In this sense, shared playful interactions that are based on joint and creative actions can create an especially fruitful platform for social, cognitive and emotional engagement.

Based on initial evidence from research, this proposal aims to investigate an overarching hypothesis, that playful interactions (in comparison to more familiar ones) have the potential to facilitate emotional and executive functioning. Our primary theoretical goal is to examine the physiological mechanisms underlying these effects, including physiological arousal linked to novelty and alertness, as well as the neurobiological bonding mechanism indicated by oxytocin levels, linked with social connection. Given the scarcity of research on social playfulness, we will examine its effects and mechanisms across ages. However, our focus is on older adults, a population at a higher risk of cognitive decline and social isolation. Crucially, even though playfulness has been consistently linked with healthy aging [10,13], most studies have been related to digital games [14], which lack the sociality and spontaneity of human playfulness. This proposal will therefore examine whether the mechanisms and the outcomes of playful interactions are evident in older age, and whether they can serve as a base-ground for meaningful social interactions for this unique population.

## 1.1 Social isolation and loneliness in old age

Social connectedness is considered to be the main key to healthy aging [15] and has been associated with decreased rates of depression [16,17], decreased risks of cognitive decline [18] and greater physical health and longevity [19]. However, as individuals age, social relationships may change for a variety of reasons. These include retirement, change in the residence of children, relatives, or friends, and death or disability among social network members. Personal factors can also restrict social interactions, such as a decline in physical and or cognitive abilities that may impair mobility and communication [1]. As a result, many older adults report on social isolation and loneliness [3]. The two terms do not necessarily entail each other. Social isolation is the objective lack of interactions with others, whereas loneliness is the subjective feeling of the absence of a social network or a companion [4]. Not surprisingly, loneliness has been associated with increased mortality and reduced functional status, depression, anxiety, stress, and increased risk of cardiovascular disease [4,20,21]. There are clear links between loneliness and cognitive decline [5,22,23] - one of the most feared aspects of aging [24]. A systematic review showed that loneliness was negatively associated with general cognitive ability, IQ, processing speed, immediate and delayed recall [5]. More importantly, the negative association between loneliness and executive function can be moderated by social interactions [25]. In other words, an increase in effective social interaction might be an asset in preserving cognitive abilities. A lack of engagement in sensory and cognitively stimulating activities, as evident in social isolation and loneliness, can lead to cognitive decline in older age [2], whereas activities that present stimulating challenges can enhance cognitive performance. This is apparent when testing executive functions, which are especially susceptible to cognitive decline in aging.

The COVID-19 pandemic is a pandemic of loneliness. Before the pandemic, national studies had already reported that 1 in 4 older adults were socially isolated and more than 40% experienced loneliness [20]. The COVID‐19 crisis has exacerbated these numbers, not only for frail individuals or those who live alone, but also among older adults with previously active or healthy social lives [26]. This research proposal will thus examine playful social interactions that target the basic dimensions of human functioning. Specifically, we will test the extent to which playfulness in social interactions in older age can withstand the shift from face-to-face traditional settings to the online video settings.

## 1.2 Playful social interactions

Playful interactions are spontaneous and flexible. They frequently express novel combination of actions that occur outside day-to day reality (such as when a parent takes the role of a child) and are accompanied by positive mood [9,10,12]. Playful interactions have been linked with physical and psychological well-being both in the general population and in older age [13,27].

Social forms of playfulness in adulthood, and a specially in old age, are typically induced by **improvised dramatic interaction paradigms** [13,28–30].Improvised dramatic interaction (hereafter, IDI) is the core of creative arts therapies (i.e., drama therapy, psychodrama and dance movement therapy) [31–33] as well as the performance arts [34]. It is based on embodied interaction, where two individuals co-create and share an imaginative world together and interact in a spontaneous way without pre-planning. The participants continuously exchange, co-adapt, and co-create; they are required to optimally allocate attention, interpret events, and to be able to make decisions about current and future actions [35]. IDI can occur on different levels - from displaying non-verbal expressions of emotions, gestures, and postures, to more verbal communication, when a real-time dialogue and narrative progression occurs [36]. Studies on IDI with younger population point to its tangible beneficial effects on several aspects of mental health, such as a reduction in depressive and anxiety symptoms and the enhancement of positive mood and psychological well-being [37,38]. A recent mixed-method study with one group of 15 older participants indicated that 8-weeks of participation in improvised playful activities yielded significant improvements in social isolation and perceived stress. Qualitative data showed that the participants experienced more attentiveness, relaxation, and an increase in cognitive stimulation and communication [39].

 Given the potential of playful interactions to improve mental health, it is surprising that research in this field is still in its infancy. The main body of evidence is mostly based on correlational studies. Furthermore, the mediating mechanisms underlying its beneficial effects are unclear. To date, there are no studies that have examined the extent to which the beneficial effects of playful interactions persist in the on-line setting. Finally, most studies on improvised playful interactions have focused on children, adolescents and young adults [37,40]. The few studies that have examined playful interactions with older adults have focused on dementia, and showed it is effective in increasing positive affect, sociability, communication and reducing depressive symptoms [41,42]. Other studies have only used qualitative methods with a small sample, showing that improvised playful interactions may help build community, provide an avenue to grow and increase positivity and feelings of acceptance [30,43].

The current proposal aims to fill this gap, through a dedicated set of studies that will examine the effects of playful interactions and their underlying mechanisms in younger and older ages. Consistent with our previous work [44–46], we will focus on a specific form of playful interaction, i.e. IDI, which allows for a high-intensity playful engagement. IDI will thus broaden our theoretical understanding on playful interactions. Using this approach, we aim to experimentally manipulate social playfulness, compare it to designated (non-playful) control interaction and map the underlying mechanisms of playful interactions and their effects on functionality.

## 1.3 Mechanisms of playful interactions

### *1.3.1 Being a creator: Novelty, exploration, spontaneity, unpredictability*

Although playful interactions take place within a basic structure of guidelines and rituals, its core characteristic is that it unfolds spontaneously and not in accordance with a set of rules [38,47]. In addition, many of the playful activities occur in a shared imaginary reality, that integrates both reality and fantasy, in which invisible imaginative dimensions of the experiences are expressed and manifested together [48]. Thus, playful interactions incorporate a high degree of novelty and exploration for participants, i.e., activities that deviate from daily routine or that were not previously experienced. The need to constantly create from scratch and resolve ambiguities calls for a high level of alertness. Unlike other situations in life, where unpredictability is linked with negative circumstances, here the context provides space for playful joyful exploration, with a sense of challenge that never crosses the line of distress.

Humans are curious and novelty-seeking creatures. We are wired to prioritize novelty [49]. Novelty has been suggested to serve as a basic human need, triggering internal motivations to explore and grow [50]. It has a wide range of effects on cognition, improving perception and action, increasing motivation, eliciting exploratory behavior, and promoting learning [51]. The attentional system is triggered by change and novelty [52,53]. Novelty is also linked with emotional arousal through the alleviation of boredom and enhancement of hedonic well-being [54,55].

Dealing with novelty and uncertainty requires alertness and recruitment of the body’s metabolic resources. Accordingly, activities involving novelty and uncertainty are characterized by physiological arousal, and in particular the activation of the sympathetic peripheral nervous system [55,56]. Research by the PIs and others have found that improvised playful interactions elicit cardiovascular and emotional arousal [57,58]. Improvised playful interactions are also associated with the flow experience - a state in which people are completely concentrated and immersed in an activity [59,60]. A number of studies investigating physiological processes during flow have repeatedly reported that flow states are associated with increased sympathetic activation [61,62], a marker of a state of increased alertness arising from the interaction of positive affect and high attention [63].

It is commonplace to find that responsiveness to novel experiences and exploratory behaviors decrease during the aging process [64,65]. However, as humans age, continued interest in novel experiences may sustain cognitive functioning, create a buffer against mental decline, and even promote longevity [66,67]. For instance, it has been demonstrated that increased responsiveness to novelty is linked with better performance in tasks involving attention and cognitive function [68]. In addition, a literature review suggested that during arousing and novel situations, the locus coeruleus releases norepinephrine that helps to protect neurons from damage and prevent cognitive decline [69]. This review concluded that interventions that increase arousal and novelty in older adults might help preserve and improve cognitive skills.

The current proposal will thus examine whether **playful interactions (as compared to more planned, familiar, and thus more predictable and less novel activities) will trigger a state of alertness characterized by elevated autonomic arousal**. We suggest that this level of alertness is marked by a sense of flow and elevated feeling of joy. We hypothesize that this mechanism will have effects on cognitive performance, specifically executive functions.

### *1.3.2 Co-creating with others*

In improvised playful interactions, the novel exploratory activity described above unfolds in the social space between participants, and is deeply grounded in it. It requires the mutual agreement and collaborative efforts of at least two parties who share a novel imaginative experience which is co-created in the ‘here and now’ [48]. Thus, a wide range of actions is possible at each moment, yet the actions do not take on their full meaning until after the act has occurred and have received a creative response from the other participant. When this happens, the participants’ inner imaginative worlds are shared and the complete meaning of the playful interaction is created [35]. Furthermore, non-verbal playful improvisation frequently involves synchronized behaviors [70,71], a powerful sensory-motor pathway linked with elicitation of intimacy, belonging, and cooperation [72].

We suggest that playful interactions can provide a remarkable space for the formation of social bonds.Social bonds with others are a fundamental human need throughout the lifespan [73]. The shared spontaneous collaborative nature of playful interactions incorporates a wide array of social functions, including social connection and belonging [71], interpersonal trust, and peer support [74], as well as empathy and the theory of mind [75]. Crucially, sharing a novel and exciting activity has been shown to result in stronger bonding and relationship satisfaction [76]. Our previous work has shown that even 9 minutes of an improvised playful interaction can significantly increase the levels of connectedness, the levels of perceived responsiveness and positive affect among older adults [44].

Building on these characteristics of improvised playful interactions and previous findings reviewed above, it is posited that playful interactions trigger the neurobiological bonding system, which underlies the formation and maintenance of close social connections. The hypothalamic neuropeptide oxytocin is known to play a significant role in the neurobiological formation of bonding via the mammalian affiliative attachment system [77]. Crucially, a plethora of studies have shown that social interactions, characterized by increased levels of social bonding, lead to an elevation in the peripheral level of oxytocin, as measured through blood tests or saliva [78]. A study conducted with one of the PIs, as well as our collaborators in this proposal, provided initial evidence that 15 minutes of improvised playful interaction can lead to reduction in loneliness and increases in levels of saliva oxytocin [79].

We will test whether playful interactions activate the neurobiological bonding system, as indexed by peripheral oxytocin and affiliative feelings. We expect that **increased bonding induced by playful interactions (with higher levels of oxytocin and affiliative feelings) will have a broader impact on social perceptions as well as positive mood**, as playfulness sets novelty and spontaneity as an engaging challenge rather than a threat.

### *1.3.3 Embodied creators*

Improvised playful interactions are expressed through the body including gestures, movements, facial expressions, eye contact and tone of voice. In this way, they encourage a shift from reflective reality in the mental domain to the real, witnessed, and executed tangible world of interacting bodies [36,80]. The embodied characteristic of the playful activity grounds high-level intense information processing about self and others in the participants’ sensory and motor experiences [81,82]. Studies have shown that abstract concepts are processed differently in the brain if the individual can experience an embodied sensory-motor interaction related to them [83]. Embodied playful action has thus been linked to an improvement of memory skills [84], even when compared with a well-matched verbal activity [85].

Non-verbal playful social improvisation frequently involves synchronized behaviors, which help the participants maintain a sense of togetherness and corporation [71]. It was found that synchronized motion can positively affect a range of emotional and social functions, such as a reduction of negative affect, an improvement of perceived and behavioral social bonding [86], and the enhancement of a range of social cognition (attention, memory, theory of mind [87]). Synchronized motion can also increase a sense of intimacy and cooperation, and is a part of building healthy interactions [72].

The central role of the body in playful interactions, as well as our previous works [44,57] and preliminary results, lead us to hypothesize that **playful interactions involving embodied elements, as compared to purely verbal playful interactions, will induce greater effects on the physiological mechanisms and the emotional and cognitive outcomes.**

## 1.4 Social playfulness in the online setting

The Covid-19 pandemic and related social restrictions, that range from complete lockdown to individual isolation, have underscored the need for online services targeted at older adults [88]. Indeed, the online environment can overcome geographic distances, mobility challenges and social restrictions. It also enables patients to cope with stigmas regarding psychosocial services, as patients do not need to physically visit the clinic or social centers [89]. Studies have shown that psychosocial interactions in the online setting can be effective in treating older adults by reducing loneliness [90] and improving social connectedness [91].

Besides the many advantages of the on-line platform, it still has several limitations. The first is the lack of a shared physical environment and copresence. Second, information quality is impoverished, and speed of the video and audio signal can diminish the transmission of nonverbal cues [92]. It is difficult for video conference technologies to transmit all sources of information at the same speed as in natural face-to-face communication [93]. Third, participants are typically only visible from the chest up, which means they have a limited frame in which to communicate. Thus, participants are unable to transmit all of the cues that are available in face-to-face interactions, such as postural cues and social context cues [92]. These limitations in input quality and contextual cues are especially detrimental for older adults [94]. There are few studies on playful activities in the online platform, and most of the literature relates to gamified cognitive training [95], which lacks spontaneity and the human playful presence. A previous study from our labs showed that aspects of processing spoken communication can be preserved in online settings, offering a set of suggestions to be implemented in online communication [96].

One of the central aims of this proposal, which cuts across studies, is to examine the robustness of social playfulness its mechanisms and outcomes to online format. Based on the preliminary results collected for this proposal (detailed in the preliminary data section), we have reasons to believe that **even in online settings, the experience of playful interaction may have positive effects upon participants**. And yet, two questions remain open: 1) the degree to which older people benefit from online playfulness, and 2) the degree to which fully embodied activities can still be beneficial in online formats. These research questions will be systematically tested in this proposal.

# 2. Research objectives and expected significance

## 2.1 Research objectives

The overarching aim of the proposed set of studies is to conduct a systematic investigation of the underlying mechanisms of playful improvised interactions and their effects on cognition, affect and social connectedness in social interactions among older adults. We will also assess the mechanisms and the outcomes of playful interactions in the online platform and at different levels of embodiment. These goals will be examined both with a younger and older population. This approach will allow us to assess age-related effects (or the lack thereof). In the current proposal, we focus on IDI paradigms, as a common social form of playful interaction with older adults. IDI provides a systematic glimpse into the core dimensions of playful interactions and are easy to implement in experimental settings. This proposal therefore aims to achieve the following goals:

(1) **Mapping the physiological mechanisms which underlie the effects of** **playful** **interactions.** Playful interactions, including IDIs, are novel, unpredictable, spontaneous and unfold in close interaction between two participants. We will examine two putative physiological mechanisms, triggered by IDIs: (A) measures of the peripheral autonomic nervous system, indicative of *physiological arousal*, including cardiovascular and electrodermal reactivity as well as indices of heart rate variability indicative of parasympathetic and sympathetic activity; and (B) changes in saliva oxytocin, as an index of the *neurobiological bonding system*. We will also collect subjective proxies of these two mechanisms: specifically, subjective arousal and affiliative feelings. Across studies we will test whether IDIs as compared to matched control interactions trigger higher activation of these mechanisms. Additionally, we will examine whether these physiological changes or subjective reports statistically mediate the effect of playful interactions on cognition, mood and social perceptions.

(2) **Assessing the effects of short-term playful interactions on cognition, mood and social perceptions.** We will examine the effects of IDIs as compared with well-matched control interactions on cognitive (executive) functions, social perceptions and mood. A large variety of tasks will be examined.

(3) **Testing** **the role of** **embodiment in playful interactions**. We will systematically examine the importance of body involvement in triggering the mechanisms and the outcomes of IDI. Specifically, we will implement an experimental design with three levels of embodiment, from purely verbal, to mixed body and verbal, to fully body with no verbal tasks. This dimension is in particularly important for the online version of the IDI interactions, due to the limited non-verbal communication in the online video.

(4) **Testing** **the scalability of playful interactions to online platforms**. We will examine whether the underlying mechanisms and outcomes of IDIs persist in online settings. Due to central importance of the online platform to modern day reality, a comparison of traditional face-to-face and online interactions will be conducted in all the studies making up this proposal.

(5) **Examining the effects of long-term practice on cognitive functions, social connectedness, and mental health indices** **among the older population**. In the last phase of the research program, we will test the efficiency of eight-week IDI practice as compared to active controls in a sample of aging participants, both in face-to-face and in online formats.

## 2.2 Expected significance

The current research aims to provide a fundamental understanding of playful interactions, their effects and underlying processes. Research in the field of social playfulness is still in its early stages. The aims of this project are to fill the gaps in the literature in five domains: 1. Examining the physiological mechanisms underlying playful interactions; 2. Examining the role of embodiment as a primary dimension of playful interactions; 3. Examining the extent to which playful interactions can have an effect in older age, given the cognitive, sensory and embodied age-related changes; 4. Examining the ability of playful interactions to have an impact with young and older adults, even after communication has been limited to an online platform; 5. Examining whether core cognitive and affective dimensions in older age are malleable through long term practice with playful interactions.

The examination of the various domains of playful interactions will lead to a novel purview of the topic. We aim to develop an evidence-based theory of playful social interactions in general and in older age. More generally, this theory will shed light on the role of novelty and embodiment in social interactions and their effect on functioning in old age. That is, we will take IDI as one example that can provide intuitions about playful interactions in general that are essential for human social, cognitive and emotional functioning.

The proposed project also has immediate and clear practical importance. In a world that is rapidly shifting to online communication, and telehealth solutions for populations at risk, creating quality online social environments has become more pressing. The results will be able to guide the design of effective social interactions for older adults (both in face-to-face and online settings) to promote cognitive and emotional performance. The findings may point to the unique characteristics of short and long-term playful interactions that can be integrated into the daily routine of the older population, in home environments, as well as in day care centers and assisted living communities. The results could have considerable importance for online therapy and learning, as IDI makes playful interactions accessible for people with limited mobility or access to psychosocial centers. This is of vital importance, as social restrictions due to the spread of pandemics, as well as mobility environmental and transportation challenges, have enormous impact on the lives of an increasing number of people around the world.

# 3. **Detailed description of the proposed research**

### 3.1 Working hypotheses

**WH1** Playful interactions (operationalized as IDI) will trigger higher levels of physiological arousal and saliva oxytocin as compared to a matched social control condition. This hypothesis will be examined using physiological and hormonal measures as well as subjective proxies (i.e. subjective arousal, affiliative feelings) in both younger and older populations across the six studies of this proposal.

**WH2** The effects of playful interactions on arousal and oxytocin will mediate the effects on executive functions, social perceptions and mood. Based on our previous findings [44,57], we hypothesize that the beneficial outcomes of IDI will be found in both younger and older populations.

**WH3** Given the central role of the body in playful interactions, we hypothesize that IDIs involving embodied elements as compared to purely verbal IDIs will have greater effects on the mechanisms and on the outcomes, both in the face to face and the online formats.

**WH4** The effects of short-term playful interaction tasks as compared to the matched social control condition will be preserved in the online format (as our preliminary results provide initial evidence for the efficiency of online IDI, see preliminary data section).

**WH5** Long- term practice with a range of verbal and non-verbal playful interaction activities will enhance executive functions, mental health indices, social connectedness, as well as openness to uncertainty, and novelty need satisfaction.

### 3.2 Research design and methods

#### 3.2.1 Participants

Table 1 presents a summary of the inclusion and exclusion criteria.The experiments described below can all be conducted at community centers, using a mobile lab [44]. A similar approach to recruitment of older populations has been successfully used in our previous projects [44–46]. Participants will receive monetary compensation for their time. Young adults will be students recruited from our academic institutes, compensated by partial academic credits and a monetary compensation for their time. The experimental procedures will be approved by the ethics committees of both institutions. Ethical procedures to protect the privacy of all participants will be closely maintained. Participants will be informed of all the details of the experimental procedure and sign an informed consent.

 To detect a significant interaction between conditions and participant groups (repeated measures ANOVA, within-between interactions, with 6 groups (6 IDI tasks in study 1,2) and 6 repeated measures), with conservative assumptions assuming a medium effect size (f2 = .20), a sample size of at least 11 in each experimental group is required to achieve a power of 0.90, using GPower, [97]. We will recruit 13 participants per group, expecting attrition.

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| **Table 1.** Recruitment of participants in the four studies. Inclusion Criteria and Background |
|  | **Older adults** | **Young adults** |
| Age | 70-85 years old | 20-35 years old |
| Language background  | High proficiency in written and spoken Hebrew, as assessed by a self-report. | High proficiency in written and spoken Hebrew, as assessed by a self-report. |
| Cognitive functioning  | a Mini-Mental State Examination above 24, to insure normal cognitive performance  |  |
| Visual and hearing abilities to allow participants to engage in an online conversation | No history of auditory or visual pathology, as indicated in a self-report.  | No history of auditory or visual pathology, as indicated in a self-report. |
| Absence of a clinical diagnosis of major psychiatric disordersand drug/alcohol abuse. | Reports by the social worker at the day care setting | PHQ-9 test with a score below 15 [98] without a diagnosis of major clinical depression |

#### 3.2.2 IDI tasks as a gauge of playful interactions

Six IDI tasks and three matching control tasks will be developed by an expert in drama therapy (one of the PIs in this proposal). All tasks will comply with the following criteria: a) easy to implement in online and offline settings; B) short, 5-10 minutes; C) the IDI task will involve co-creation, spontaneity and novelty while the control task will be in the form of a more familiar interaction. The tasks will differ on the embodiment dimension, allowing us to examine whether embodied IDIs tap into similar mechanisms and produce similar effects as verbal IDIs.

Two IDI tasks will be administered mainly in the verbal domain, such as an association task [40]. The verbal control task will consist of a mundane social interaction on similar topics. Two other IDI tasks will involve a mixture of verbal and non-verbal activities (as in the preliminary results reported below). The matching control task will also involve verbal and non-verbal elements, but with low levels of novelty and spontaneity. Two additional IDI tasks will mainly involve the body domain, such as the mirror game task [57]. The nonverbal control task will be a mundane nonverbal activity, such as a guided exercise [44]. The separate levels, verbal-mixed-nonverbal, will allow for a systematic investigation of the effects of the embodiment dimension of IDI activities as well as its scalability to the online interaction.

All sessions will be conducted by trained drama therapy students with extensive experience in IDI practices.

#### 3.2.3 Measurements

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| **Table 2.** Type measurements for each study |
| **Type and Study** | **Measurements**  |
| **Physiological measures**Study 3,4,5,6 | 1. **Hormones:** Saliva samples for **oxytocin** will be collected via dry drill and stored until assay, following well-validated lab protocols.
2. **Physiological arousal:** cardiovascular (HR) and electrodermal (EDA) measures will be recorded and pre-processed in accordance with validated and published routines in our lab [99–101]. A series of reactivity measures will be derived, including **cardiovascular** (HR) and **sympathetic** (EDA) **activation**, as well as **heart rate variability indices indicative of parasympathetic** (RSA) and sympathetic (low frequency HRV) activity.
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| **Subjective proxies**Study 1,2,5,6,7,8 | 1. **Flow Questionnaire** [102]; a 9-item questionnaire that measures people’s perceived state of flow in a specific context. The scale items reflect the nine flow factors [60]. Participants will be asked to rate items such as “I felt like time passed quickly,” “I really enjoyed what I was doing” on a seven-point scale, from 1 (strongly disagree) to 7 (strongly agree). Flow will serve as a manipulation check.
2. **Subjective Arousal** will be measured using a 0-100 VAS scale.
3. **Affiliation**. Participants will rate the extent to which they felt closeness, similarity and rapport during the session towards the RA, on a 9-point Likert scale. In our previous study the Cronbach’s alpha was 0.89 [103].
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| **Mood**Study 1,2,5,6,7,8 | **Mood** will be assessed on the Positive and Negative Affect Schedule [104], a self-report inventory divided into two subscales assessing positive and negative affect. The inventory consists of 10 items for each subscale, scored on a scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). In our previous studies the Cronbach’s alpha for positive affect ranged from 0.81 to 0.86 and for negative affect from 0.77 to 0.81 [45]. |
| **Social perceptions**Study 1,2,5,6 | **Perceived Partner Responsiveness** [105]. A 4-item questionnaire examining the participants’ subjective assessment of the RA’s responsiveness to them (during the session). The PPRS was used in our previous studies to assess the development of a relationship specifically after interactions between unfamiliar partners. Cronbach’s alpha in previous study was α = 0.80 [44]. |
| **Cognitive measures**Study 1,2,5,6,7,8 | **Cognitive tests for Study 1, 2:** forward and backward digit span, word-pair delayed recall and phonetic fluency taken from the Hebrew version of the WAIS-IV. We will also include a colour-word Stroop test (adapted by [106] and spoken word discrimination in noise (taken from [44]. **Cognitive tests for Studies 5, 6**: based on the pre-tests and the results of studies 1 and 2, we will choose three of the above-mentioned main tests for executive functions. **Cognitive tests for Study 7, 8:** a battery of cognitive tests will be used to carefully examine changes on a variety of executive domains. These include the above-mentioned tests with the addition of the Continuous Performance Test (CPT, [107]) the Attention Network Test (QANT [108]), and the E-WINDMIL, a standardized test for speech processing in noise under a cognitive load as conducted in PI3's lab [109].  |
| **Openness to experience**In all studies | This trait will be controlled in all studies, as it was found to influence on the involvement of participants in playful and creative activities [111]. The trait will be measured on the 10-item openness to experience subscale of the Big-5 questionnaire [110]. Participants will be asked to indicate the extent to which they agreed with each of the statements about how they see themselves, on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). A sample item is: “I see myself as someone who values artistic, aesthetic experiences.” The Hebrew version of the questionnaire has good internal consistency, α=0.78 [111] |
| **Novelty Need satisfaction scale**Study 7,8 Before and after the long-term practice | **Novelty Need satisfaction scale** [50]. The inventory consists of six items, such as “I think I discover new things frequently” scored on a scale ranging from 1 (not at all true) to 7 (very true) with a composite reliability of ρ = 0.90.  |
| **Uncertainty tolerance**Study 7,8Before and after the long-term practice | **Uncertainty tolerance scale** [112]. Participants will be asked to rate eight items assessing worry and threat linked with uncertainty, such as “I like change and excitement,” “I like to try things out, even if nothing comes out of it.” Participants will rate each item on a six-point scale, from 6 (strongly agree) to 1 (strongly disagree). The questionnaire was found to have a good reliability (Cronbach α = .743).  |
| **Mental health indices** Study 7,8Before and after the long-term practice | **Psychological and Social Well-being** [114] – In this study we will examine two of the six dimensions: positive relationships with others and personal growth. Participants will rate to nine statements for each subscale, such as “I think it is important to have new experiences that challenge how you think about yourself and the world” for the personal growth subscale, and “People would describe me as a giving person, willing to share my time with others” for the positive relationship with others subscale. Each item is scored on a scale ranging from 1 (*completely disagree*) to 6 (*completely agree*). In our previous study, the Cronbach’s alphas for the relationships with others subscale ranged from 0 .69 to 0.84; and for the personal growth subscale from 0.72 to 0.87 [45].**Geriatric Depression Scale** [115] - a short version to measure depressive symptoms. This self report inventory includes 15 yes/no questions, such as “Have you dropped many of your activities and interests? YES / NO”. In our previous study, the Kuder-Richardson’s coefficients ranged from 0.66 to 0.76 [45].**Basic Psychological Need Satisfaction and Frustration Scale** [117]. This questionnaire consists of 12 need satisfaction items: four items for each basic psychological need (autonomy, relatedness, and competence) such as “I feel a sense of choice and freedom in the things I undertake”; and 12 need frustration items: four items for each of the basic psychological needs, such as “I feel like a failure because of the mistakes I make”. Participants rate each item on a 5-point scale, indicating the extent to which their psychological needs are satisfied or unsatisfied in their lives from 1 (*completely disagree*) to 5 (*completely agree*). The Hebrew version of the questionnaire has good internal consistency, ranging from α=0.78 to α=0.84 [118]. |
| **Social connectedness** Study 7,8Before and after the long-term practice | **1) The Duke Social Support Index** (DSSI) [119]. We will use the subjective support subscale, which consists of 14 yes/no items, such as “Do family and friends understand you”? scored on a scale ranging from 1 (*hardly ever*) to 3 (*most of the time*). The Cronbach’s alpha for the perceived social support subscale was 0.79 [120]. **2) UCLA Loneliness Scale** [121]. Loneliness and satisfaction with relationships will be measured on the revised version of the UCLA Loneliness Scale. This self-report inventory includes 20 statements, scored on a scale ranging from 1 (*never*) to 4 (*often*). Ten items measure loneliness (dissatisfaction with social relationships) such as “I lack companionship”and 10 items measure satisfaction with social relationships such as “I feel in tune with the people around me”. The Cronbach’s alphas in our previous study for loneliness ranged from 0.81 to 0.85 and for satisfaction with social relationships from 0.70 to 0.89 [45]. |

#### 3.2.4 Description of studies

Eight experiments will be conducted. In each experiment the IDI will be assessed in comparison to matched social interactions that are not based on novelty and spontaneity.

1. **Short term effects of IDI in a younger population (Studies 1, 2)**

Studies 1 and 2 will examine: a) the effect of IDI as compared to a matched social control condition on executive functions, social perceptions and mood (WH2) as well as on the subjective proxies of the proposed mediating mechanisms, i.e., subjective arousal, flow and affiliation (WH1); b) the extent to which these effects will be preserved at different levels of embodiment (WH3). c) the extent to which these effects will be preserved in the online format (WH4). Studies 1 and 2 will be conducted in a convenience sample of young adult students to conduct an initial validation of the design by employing a wide array of IDI tasks (six different tasks will be tested). The variety of tasks used will allow us to examine the effect of embodiment on IDI mechanisms and outcomes. Study 1 will be conducted in a traditional face-to-face (F2F) setting, Study 2 will examine the scalability of the IDI tasks to online formats.

Studies 1and 2 will include 66 participants (recruiting 78) each in a 2x3 mixed design, with embodiment serving as a between factor and condition as a within factor. Each participant will take part in one of the six IDI tasks and a matching control task. The IDI and the control sessions will be administered in a counterbalanced order across participants separated by one week. The effects of embodiment will be examined across participants. Mood, subjective arousal, flow and affiliation measures, as well as the cognitive tasks will be collected before and after each session.

1. **Physiological mechanisms underlying IDI in younger population (Studies 3, 4)**

The aim of these studies is to identify the physiological mechanisms in different IDI tasks (WH1) in F2F (Study 3) and online (Study 4) formats (WH4). Based on the results of Studies 1 and 2, one IDI task will be chosen. Each experiment will include 33 participants in a within-subjects design, with condition order (IDI, control) counterbalanced across participants. Upon arrival to experimental session, participants will be connected to physiological equipment and fill in pre-test questionnaires. Ten-minute physiological baseline measures will be collected, after which participants will provide saliva samples. They will then undergo the IDI or cIDI task, which will be followed by filling in self-reports, a five-minute physiological baseline and second saliva samples.

1. **Short term effects and physiological mechanisms of IDI in an older population (Studies 5, 6)**

Study 5 and Study 6 will test older adults and compare performance across the two age groups. The aims of these studies are to examine a) the effect of IDI as compared to matched social control conditions on executive functions, social perceptions and mood among older adults (WH2); b) the physiological mechanisms mediating these effects as well as subjective proxies of the proposed mediating mechanisms, i.e., subjective arousal, flow and affiliation (WH1); c) the effects of embodiment on mechanisms and outcomes (WH3). d) the extent to which these effects will be preserved in the online format (WH4). Study 5 will be conducted in a traditional F2F setting. Study 6 will examine the scalability of the IDI tasks to online formats.

Based on the results of Studies 1 and 2, as well as small-scale pilots, we will choose three IDI tasks with the best outcomes and adapt the guidelines to the older population if necessary. Studies 5 and 6 will each include 33 participants in a within-subjects design. Each participant will take part in one of the three IDI tasks and a matching control task. Upon arrival, the participants will fill in the pre-test questionnaires and the cognitive assessment test, 10 minutes of physiological baseline measures will be collected, after which participants will provide saliva samples. They will next undergo the IDI or cIDI task, which will be followed by filling in self-reports, three minutes of physiological baseline, a second saliva sample and the post cognitive assessments.

1. **Long term effects of IDI in an older population (Studies 7, 8)**

Based on the results of the previous studies we will develop an extended IDI-based program. This study will examine the effects of long-term practice with various verbal and non-verbal IDI activities on executive functions, mental health indices, social connectedness, as well as openness to uncertainty and novelty need satisfaction (WH5). The experiment will be run in F2F (Study 7) and online (Study 8) formats. Participants will engage in a combination of verbal and non-verbal IDI activities twice a week for four weeks. Each session will last 30 minutes and will be conducted at day care centers or the assisted living communities. Each study will involve 80 participants (anticipating high attrition, common in long-term studies), randomly divided into an experimental and active control group in a between-subjects design. State self-reports will be assessed before and after each session (similar to Studies 5,6). Mental health indices and cognitive assessments will be conducted before and after the interventions. We will also assess group differences on the uncertainty tolerance scale, novelty need satisfaction scale and social connectedness following the experiment.

#### 3.2.5 Statistical analysis

To test the effects of playful interactions, operationalized as IDI, in all of the above measures and experiments we will use various tools. As we do not wish to assume equality of variance and a normal distribution, we will apply a mixed-level linear model (MLM). The various measures (cognitive, social, emotional, and physiological measures) will serve as the dependent variables; age group (young vs. older adults), types of tasks (type of IDI) and platform (online or F2F) as the between participant variables, and time of testing (before vs. after) and experimental condition (IDI vs. control) as the repeated measures. In some models (when analyzing the results of Studies 5 and 6), physiological measures will serve as mediating factors, to test their role as the underlying mechanisms for change in the dependent variables.

### 3**.3 Preliminary data**

**Previous findings from our labs:** Our earlier studies in the field focused on one specific playful social interaction, a dyadic playful activity, which includes synchronized motions of improvised movements, common to theater performance arts and therapy. The results of our first study indicated that a mirror-game of 9 minutes was sufficient to enhance mood and social indices among older adults, as well as attentional functions as compared to an exercise class activity-representation [44]. A second study indicated that a short-term mirror-game of 15 minutes with older adults led to a reduction in sense of loneliness and changes in levels of saliva oxytocin. More specifically, the results showed that changes in oxytocin predicted a reduction in emotional loneliness in cases where individuals experienced high levels of closeness and synchrony during the mirror game [79].

**Preliminary data on online improvised dramatic interactions:** In a pilot study consisting of an initial examination of the proposed mechanisms, as well as the effects of playful social interactions in the online settings, 21 participants [ages 19 to 75, 9 males], met with a research assistant (RA) on the Zoom video platform for two experimental sessions, two days apart. In each session they engaged with a new RA for one activity (lasting ~5 minutes): 1) IDI involving both verbal and non-verbal elements where participants were asked to describe their three favorite activities, invent a movement for each of them, and teach the RA the movements; then they switched roles. Finally, the participant and RA performed a shared “movement-story”, created out of the movements they taught each other; 2) a control activity, in which the participant and the RA were asked to describe their three favorite e activities and the last time they engaged in them. The order of conditions and the assignment of RAs to the activities was counterbalanced across participants. Mood and arousal measures were collected before and after each activity. After the activity, the participants filled in a series of questionnaires on flow, affiliative feelings, social presence and perceived partner responsiveness. The results provided clear support for our hypotheses. First, there was a significant time x condition interaction for positive mood, F (1,20) = 8.75, *p* = .008, *ƞ2*= .3, and arousal, *F* (1,20) = 5.1, *p* =.034, *ƞ2*= .2, suggesting an IDI-related increase in both. Planned comparisons indicated that IDI elicited a clear and significant increase in positive mood, *t* (20) = 5.9, *p* < .001, and arousal, *t* (20) = 4.7, *p* < .001) that was not observed in the control condition (*p* >.25, for all comparisons) (Figure 1).

Second, the results indicated that IDI as compared to the control condition was characterized by higher feeling of flow, *F* (1, 20) = 12.07, *p* =.002, *ƞ2* = .37. Third, IDI was found to lead to significantly increased indices of social bonding, including affiliative feelings (*F*(1, 20) = 10.7, *p* =.004, *ƞ2*= .35), social presence (*F*(1, 20) = 13.1, *p* = .002, *ƞ2* = .395) and perceived partner responsiveness (*F*(1, 20) = 8.3, *p* < .009, *ƞ2*= .29). These preliminary data provide initial strong support for our hypothesis that online playful interactions activities, as compared to more standard social interactions, can have enhanced effects on positive mood, arousal, immersion in the activity and social connection. To the best of our knowledge, our data constitute the first study on the impact of online improvised dramatic playful interactions.

Playful interaction

Control

**Figure 1.** Comparison of on-line IDI and control condition on subjective arousal and positive mood. Means before and after the IDI and control condition.

### 3.4 Expected results

The proposed set of studies is expected to have real-life implications for interventions and for online communication from adulthood to older age. Our conclusions will aid in the construction of guidelines that can help to develop new programs and assist professionals, therapists and care providers in promoting better social interactions across platforms and social domains. In light of the increase in online platforms as a means of social interaction and medical and therapeutic services, and the debate over the meaningfulness of social interactions in online platforms, the findings will also be informative regarding the role of playful interactions in such communication. These evidence-based results are expected to result in future interventions aimed at preserving and improving cognitive skills, as well as social and emotional well-being in older age and individuals with mobility restrictions. This of high importance given the increase in life expectancy worldwide, and the challenges faced by communities including older adults in modern society. The proposed project is expected to make a significant theoretical contribution to the understanding of the processes underlying playful interactions. Finally, as evident in the research plan, the studies will culminate in several manuscripts submitted to top-tier peer-reviewed journals. We also aim to publish a purely theoretical manuscript at the end of the 4-year project providing a new viewpoint on playful interactions generally, and IDI specifically. We also aim to present the results in other venues (conferences, workshops, information sheets) to encourage professionals to implement our conclusions in their work, to generate real life changes.

### 3.5 Pitfalls

Some of the proposed measurements may not trigger the main effect. For that reason, the experiments have a stepwise structure, so that if we do not obtain a main effect in one of the measurements in the younger population, we will not examine this measurement with the older population. For example, we know that changes in oxytocin are dependent on various variables including time of day and other subjective conditions. If we realize in the early stages of the first studies that the IDI tasks do not trigger higher changes in oxytocin levels as compared to other social interactions, we will not examine oxytocin levels with older adults. Second, the first six studies are based on short-term IDI tasks with a duration of several minutes. In those studies, we plan to measure several indices including psychological batteries, self-reports, and cognitive tests. As many measures are planned for these early studies, we will choose a subset of valid and brief tests for later studies. Third, there are test-specific aspects that need to be addressed. Cognitive tests for example were found to have an impact on mood, in a way that might interfere with other measures. Physiological indices must be measured immediately after the task, since the effect is temporary. To cope with these challenges, the first four studies, conducted with young adults will use different outcome measures: Studies 1,2 will focus on self-reports and executive function, while Studies 3 and 4 on physiological effects. Based on the results of Studies 1 to 4, a short battery of tests (as described above) will be chosen for Studies 5 and 6 conducted with older adults. Fourth, our control social interactions conditions might also elicit changes in some of the DVs. If the effect of the social interactions is too strong, our conclusions will confirm the literature on the importance of social interactions, and we will change our control conditions to less interactive tasks (such as reading a text or participating in a exercise class).

### 3.6 Resources available for research

***Collaborations.***This proposal will be conducted in collaboration with Prof. Ruth Feldman and Dr. Orna Zagoori-Sharon from the Center for Developmental Social Neuroscience during the testing and analysis of saliva oxytocin. ***IRB.***Our studies will obtain institutional review board approval from the University of Haifa and Reichman University. ***Apparatus****.* Professor Ben-David and Dr. Golland have lab equipment at the Reichman University lab complex. These include the auditory and physiological equipment for the studies. In addition, a mobile lab for physiological assessments in the field is also available. ***Professional staff.*** Our interdisciplinary team combines expertise from different schools of thought. Dr. Keisari is an expert in drama therapy and is experienced in developing and conducting short and long term creative and playful interventions for the older population. Professor Ban-David is an expert on cognitive aging, cognitive measures and verbal interpersonal communication across the life span. Dr. Yulia Golland is an expert on the psychobiological mechanisms of naturalistic social interactions, motor and physiological synchrony as well as the autonomic metrics underlying emotional and social processes. ***Access to participants.*** In the past ten years, our team at Haifa has accumulated a pool of older participants and care settings who have participated in several studies that involved examinations of drama and theater techniques. In addition, the Reichman lab has a large pool of native Hebrew speakers who are willing to participate in research.

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