The Right for Aging: Investigating the Interrelations between Negative Aging Stereotypes, Perception of Aging, Older Adults' Cognitive Performance and Impacts of Cognitive and Exercise Interventions

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Abstract of the Thesis

The Right for Aging: Investigating the Interrelations between Negative Aging Stereotypes, Perception of Aging, Older Adult's Cognitive Performance and impacts of cognitive and exercise interventions

Anne Julien, for the Doctor in Philosophy (Psychology), Concordia University, 2023.

While research on patterns of cognitive decrements in later life has focused on biological processes, psychosocial processes, such as negative aging stereotypes (NAS), an individual's learned beliefs about the characteristics or attributes of older adults as a group, and self-perception of aging (SPA), the cognitive evaluation of oneself relative to aging, have also been associated with poorer cognitive performance, decreased well-being, and disengagement from healthy behaviours. For example, it is suggested that NAS is negatively related to verbal memory performance in older adults, although little is known about its potential relationship with other cognitive domains. Furthermore, usual methodologies do not align with clinical procedures, creating a gap between research and clinical settings. Additionally, the literature supports satisfaction with aging as a central aspect of subjective well-being in older age but remains understudied despite evidence of internalized ageism among older adults. Importantly, evidence concerning ways to improve NAS and SPA in older adults is lacking. This is problematic, given that psychological processes may be particularly amenable to interventions.

The first manuscript of this thesis explores the relationship between NAS and SPA, and older adults' cognitive performance. More specifically, we measured explicit and implicit NAS and SPA in older adults. We assessed their verbal and visuospatial memory, working memory and processing speed using a clinical framework. Results showed that higher explicit NAS negatively correlated with verbal and visuospatial memory and processing speed. Explicit NAS predicted processing speed and visuospatial memory, while implicit NAS predicted verbal memory.

The second manuscript investigated the effect of aerobic, gross motor abilities, or cognitive training on changing NAS and SPA. Results suggested that a 3-month regimen of either training type led to improvements in SPA independently of better fitness and cognition. On the other hand, NAS remained stable.

Despite best clinical practice, older adults come into the assessment room with beliefs that may adversely related with their cognitive performance beyond verbal memory. However, SPA can be improved through various types of training, which could reach a broader range of older adults with multiple interests and initial abilities.

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Authors' Contributions

AJ completed the literature review and elaborated the project design in collaboration with LB, KP and SD. AJ was involved in participants' recruitment and initial interviews, cognitive testing, and questionnaire administration. AJ scored and entered all cognitive data and questionnaires. AJ conducted all statistical analysis and consulted with NK and LB for data analysis and interpretation. AJ wrote the manuscript. KP, NK, SD and LB reviewed the article "Investigating the Effects of Negative Age Stereotypes on Older Adults' Cognitive Performance." The same authors and NB reviewed the article "Exercising your Perception of Aging: Effects of Physical and Cognitive Training on Older Adults' perception of their Own Aging." LB reviewed the General Introduction and Final Discussions sections.

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General Introduction

From the very first moment we live, we are aging. This process is interpreted as growth in earlier developmental stages and elicits praise. However, it comes a day when aging begins to carry a different social meaning of falling back or breaking down (Lindland et al., 2015). Indeed, aging is not only a senescence process but is also embedded in a social context and shaped by social factors (Ayalon & Tesch-Römer, 2018). Older adults face negative aging stereotypes (NAS), which can impact the perception of themselves and their daily functioning. Stereotypes refer to the generalization of characteristics to an entire group while neglecting the heterogeneity of the targeted group. These assumptions and beliefs ignore the multiple and unique courses of the aging process, leading older adults to be treated stereotypically and even colour their expectations about aging. At the root of ageism, NAS fuels power imbalance and discrimination.

As the population of adults aged 60 years and older is growing rapidly, doubling from 1980 and projected to represent around 22% of the worldwide population in 2050 (World Health Organization, 2015), understanding ageism has become a pressing social issue (Levy & Macdonald, 2016). Robert Butler, a pioneer in aging research, was the first to define ageism as "prejudice by one age group against another age group" (Butler, 1969, p. 243). He also suggested that ageism was linked to youth's revulsion for growing old, disease, disability, and fear of powerlessness, uselessness, and death. Butler (1980) had worked to bring scholars' attention to ageism, a work that was pursued by Nelson (2005) when he called upon the field to make more progress in understanding ageism. In the past 20 years, more scholars in multiple countries have documented forms of ageism in their respective countries, and research has expanded significantly (Levy & Macdonald, 2016). In 2016, the World Health Organization was mandated to fight ageism, given the increasingly convincing evidence that ageism is harmful at the individual and societal levels. Ageism has been shown to affect older individuals' well-being, social life, quality of life, health and mental health services received, sexuality, and survival. At the societal level, it has been shown to create division between generations and establish power imbalance, decrementing older adults and preventing them from living their full potential (Ayalon & Tesch-Römer, 2018). It is also estimated to cost up to 63 billion dollars to American society, increasing the prevalence of health conditions such as cardiovascular diseases, chronic respiratory diseases, musculoskeletal disorders and mental disorders (Levy et al., 2020). Unfortunately, ageism is the most condoned and well-institutionalized form of "-ism" and is generally accepted (Angus & Reeve, 2006; Hagestad & Uhlenberg, 2006).

Theories Behind Ageism and NAS Internalization

Ayalon and Tesch-Römer (2018) have suggested three levels of ageism: the macro-level, which relates to societal and cultural values (e.g., political regulations), the meso-level, which focuses on groups, organizations, and social entities (e.g., the domain of education or work), and the micro-level, which focuses on the individual's thoughts, emotions, and behaviours. Only the micro-level will be discussed in this thesis (see Ayalon & Tesch-Römer, 2018, chapter 1, pp. 6-8) for the meso- and macro-level.

Different theoretical approaches from social psychology could explain the occurrence of ageism (Ayalon & Tesch-Römer, 2018). According to the *Terror Management Theory*, older adults are considered a constant reminder of one's finitude, mortality, or vulnerability. Individuals manage the anxiety induced by older adults' presence by sustaining beliefs in cultural worldviews offering literal or symbolic immortality. Individuals adhere to these cultural worldviews and attempt to increase their self-esteem, providing a buffer against death-related anxiety. This allows the person to maintain relative calmness and serenity despite awareness of their vulnerability and mortality (Greenberg et al., 1986; Greenberg et al., 1997). The *Stereotype Content Model* proposes that people are classified based on levels of warmth and competence. In the case of older adults, individuals are commonly seen as being warm and incompetent, which leads to feelings of pity and sympathy towards them (Cuddy & Fiske, 2002; Fiske et al., 2002). In the *Social Identity Theory*, individuals act as reference group members, which goes beyond behaving based on their characteristics or interpersonal relationships. In this perspective, group membership is at the root of the individual identity composing this group and determines the individual's relationships with members of other groups (Tajfel & Turner, 1979). To achieve a positive self-identity, people demonstrate biases that create positive distinctions for their ingroup and elevate their ingroup's status above other groups' (Kite et al., 2002; Tajfel & Turner, 1979). The *Social Identity Theory* may explain ageism since age may be used as a characteristic to label groups (Lev et al., 2018).

In these three theories, the concept of learned associations (old and death, old and warmth, and old as a group) develops through time. This is coherent with the human development tradition in psychological research that emphasizes changes over time, suggesting that ageism originates in childhood, and its outcomes may change over the life course (Ayalon & Tesch-Römer, 2018). The *Social Developmental Perspective* proposes that perceptual, affective, and sociocultural mechanisms are responsible for the development of ageism throughout the life course, and age-based classification is believed to be universal (Montepare & Zebrowitz, 2002).

The Stereotype embodiment theory (Levy, 2009): How NAS makes its way to self-perception. The two articles of this thesis used the *Stereotype Embodiment Theory* (Levy, 2009) as background theory. This theory stipulates that NAS is internalized at a young age and undergoes reinforcement in one's lifetime through the observations of the way older adults are treated in one's social culture. NAS is believed to operate unconsciously, gain salience from self-relevance, and use physiological, behavioural, and psychological pathways (Levy, 2009). Lifetime exposure to NAS leads to the internalization of ageism and has been shown to damage self-perception of aging (Kotter-Grühn & Hess, 2012). Self-perception of aging (SPA) translates the degree of satisfaction with one's aging and reflects adaptation to age-related changes (Levy, 2009). In the Stereotype Embodiment Theory, Levy (2009) proposes that SPA is a "manifestation of internalized age stereotypes" (Sargent-Cox et al., 2013), as NAS is assimilated and included as an accurate representation of one's identity (Levy, 1996), and proven stronger than actual experiences (Levy, 2003a). Indeed, stereotypes learned in youth create expectations about the future, which may develop into a self-fulfilling prophecy (Bennett & Gaines, 2010; Levy & Leifheit-Limson, 2009). When a person identifies as an older adult, stereotypes can function as a motivational incentive for behaviour (Hoppmann et al., 2007) or as a reference standard to evaluate actual experiences (Freund & Baltes, 2007). It appears that declining aging trajectories also reach a certain consensus cross-culturally. College students across 26 cultures reported perceptions of age-related decline in physical, cognitive, and socioemotional areas of functioning. This included a perceived decline in societal views of aging, physical attractiveness, the ability to perform everyday tasks, and new learning (Löckenhoff et al., 2009).

Longitudinal studies have shown that NAS and negative self-views of aging among older adults were related to poor health, low well-being, and shorter survival times (Levy et al., 2012; Marchiondo et al., 2017; Sargent-Cox et al., 2013; Wurm & Benyamini, 2014; Wurm et al.

2010), decrements in cardiovascular health (Levy et al., 2009), detrimental brain changes such as the accumulation of plaques and tangles, and reduction in the size of the hippocampus (Levy et al., 2016) and exacerbated stress overtime (Levy & Bavishi, 2018; Levy et al., 2016).

How do NAS and SPA Impact Cognitive Performance?

In the context of aging, it was experimentally demonstrated that NAS and more negative SPA would adversely affect the cognitive performance of older adults (Barber et al., 2015; Haslam et al., 2012; Horton et al., 2008; Mazerolle et al., 2016). Research has focused on how negative beliefs about one's membership operate from self-concept to behaviour. Stereotype threat is believed to be a process by which NAS works (Steele & Aronson, 1995). Stereotype threat describes a situation in which there is a negative stereotype about one's group. This person is concerned about being judged and treated negatively according to this stereotype (Spencer et al., 2016) or that poor performance on their part will confirm a negative, self-relevant stereotype (Steele, 2010; Steele & Aronson, 1995; Steele & Aronson, 1997). In response to this threat, people tend to underperform compared to their potential, thereby conforming to the stereotype. This was first illustrated by Steele and Aronson (1995). They demonstrated how African American students performed below their potential on the Scholastic Aptitude Test when stereotypes about their intellectual abilities were emphasized. They found that those not exposed to the threat performed at the same level as the Caucasian students. Subsequently, stereotype threat effects have been studied across various stereotyped social groups, including women, gay men, individuals from low socioeconomic status, and older adults (ed. Ayalon & Tesch-Römer, 2018).

Steele and his colleagues theorized that targets of the threat might often be unaware of the source of the threat (Steele, 2010; Steele, 1997; Steele CM et al., 2002a). In other words, a threat may arise from any situational cue indicating that one is at risk of being judged based on negative stereotypes about their social identity. People tend to be sensitive to signals that their identities may be devalued in each situation (Purdie-Vaughns et al., 2008; Wout et al., 2009), suggesting that cues do not necessarily need to be blatant to trigger stereotype threats (McGlone et al., 2006). It appears that one's group identity, a social context where the stigma is present and self-relevant, and a setting in which a stereotype could be confirmed are enough to pose a risk to the individual's performance (Steele & Aronson, 1995).

In the context of aging, going through a cognitive assessment offers a favourable setting to trigger a threat. A meta-analysis by Lamont et al. (2015) has shown that NAS consistently impairs older persons' performance across various domains such as physical, skill acquisition, driving, cognitive, and memory (d= 0.28). More recently, a meta-analysis by Armstrong et al. (2017) reported that stereotypes impact different forms of memory, such as episodic and working memory. The authors were interested in potential moderators of age-based stereotypes, some including types of stereotype manipulation (blatant or subtle). They found that the effect of the age-based stereotype on episodic memory tasks was only significant when blatant manipulations were used. However, subtle manipulations were enough to impact working memory tasks negatively. These findings align with McGlone et al. (2006). They provided evidence that blatant and subtle cues were harmful to performance, although probably through separate mechanisms and simultaneous detrimental effects on performance (Stone & McWhinnie, 2008). In the case of Lamont et al. (2015), the authors categorized NAS into fact-based and stereotypes-based influences. Fact-based seems closer to Armstrong et al. (2017) blatant activation, as it refers to the explicit presentation of factual statements of age-based differences that affect participants' expectations about performance. For example, a methodology using fact-based manipulation could have a researcher clearly state to older participants that research has reliably shown that memory declines with age.

Stereotype-based manipulation is closer to Armstrong et al. (2017) subtle manipulation. Here, societal stereotype statements are used to decrement one's performance due to more significant ambiguity and uncertainty about applying the NAS to the individual. Participants may get the information that a decline in memory performance in aging is widely assumed in society, or even more subtle, informing an older participant that a younger one is currently completing the same task. Lamont et al. (2015) concluded that regardless of the degree of subtlety, stereotype-based threats produced significantly greater performance decrements than fact-based manipulation. This occurred probably by increasing distracting thoughts that potentially interfered with working memory (Hirsh et al., 2012) and depleted cognitive resources involved in the task (Schmader et al., 2008). However, Hess et al. (2003) reported that neutral priming could negatively impact cognitive performance. This study's older participants were primed with negative, positive, and neutral priming methods before a cognitive test session. Confirming the authors' hypothesis, participants negatively primed showed a decrease in their cognitive abilities in the following word memorization test. Interestingly, neutrally primed individuals also exhibited a more minor but negative effect on their cognitive skills. Hess et al. (2003) suggested the possibility of a threat being operative even without explicit exposure to NAS.

This is coherent with earlier work supporting that instructing participants on stereotypes and manipulating stereotypes is often superfluous to capture a threat in the laboratory (Spencer et al., 1999; Steele & Aronson, 1995). Spencer et al. (2016) mentioned that simply sitting down to undergo a test in a negatively stereotyped domain is enough to trigger a threat, given that the examinee is at risk of confirming the stereotype through poor performance. Especially in the case of aging, cognitive assessment appears to represent a real-world setting requiring no special instructions to trigger a threat since it is commonly vehiculated that older adults decline in their cognitive abilities with the aging process. Under normal testing circumstances, and more so in older adults who value their cognitive abilities, individuals risk seeing their performance impeded.

Mental health professionals assessing older adults' cognition must consider mood, sleep, stress, or motivation as potential factors impacting a patient's performance. These variables contextualize a given performance and offer a better understanding of a patient's cognitive functioning; thus, suitable patient care recommendations can be made. Given the accumulated data supporting that NAS and SPA impact older people's cognitive performance, it could be relevant to include these variables in the neuropsychological battery.

Intervention: Changing Older Adults' NAS and SPA

Psychoeducation and intergenerational contact intervention. These interventions provided promising results in reducing NAS and changing how older adults perceive themselves. The contact hypothesis (Tausch & Hewstone, 2010) promotes social interactions between the stigmatized group and the other groups believing the stereotypes. This intervention has been shown to change the negative attitudes and prejudices toward members of the stigmatized group through decreased anxiety and increased empathy and knowledge regarding this group (Kotter-Grühn, 2015) and more positive changes in attitudes and NAS for older adults. The benefits appear optimized when used concomitantly with education about aging stereotypes (see Burnes et al., 2019, for a systematic review and meta-analysis).

However, changing views of aging not only involves learning reliable information about developmental aging. Change is not just about "knowing" but also involves "processing" the information. It involves not only being "told" about the inaccuracy of a stereotype but "experiencing" its inexactness through a situation favourable to learning and growth. In the line of aiming at giving back control to older adults and helping this population to crosscheck their assumptions about what they can or cannot do, there is a need to develop interventions that can be accessible at low cost and committed to, with autonomy. What is suggested is not going against what has already been supported in the literature: the benefits of intergenerational contact and psychoeducation. Still, it is meant to supplement or give alternatives to those not having the possibility to access these services, which puts older adults back in a place of depending on others for their health. If being physically active is associated with lower negative affect and stress and better SPA, and if cognitive training was linked to improved perception of daily cognitive performance, these interventions could potentially address the processes of maintaining NAS and lower SPA.

Is increasing active aging to challenge NAS and SPA a win-win intervention? Having older adults engage in physical activity is one of the significant challenges in our contemporary societies (Forberger et al., 2017), and NAS has been identified to interfere significantly with older people's commitment to exercising. Satisfaction levels with one's aging tend to decrease throughout life, coinciding with less attention to the individual's health care (Kim et al., 2014; Levy & Myers, 2004; Wurm et al., 2010; review Dionegi, 2015). Accordingly, developing interventions to fight ageism, decrease NAS and promote positive SPA is increasingly viewed as a critical component of healthy aging (WHO, 2015). Despite evidence of the benefits of NAS reduction and SPA improvements on health, obstacles remain to older adults' commitment to healthy behaviours.

A major misconception about older adults' development is that age-related changes are beyond the individual's control. However, decades of research have shown how lifestyle factors and behaviours account for more variance in health-related and psychological outcomes than genetics (Diehl et al., 2020). Despite this, older adults progress into this developmental stage with poorer health, lower well-being, and shorter survival times (Levy et al., 2014; Wurm et al., 2010), believing that there is nothing they can do to age more positively. This is not to recall the Stereotype Embodiment Theory (Levy, 2009) and consequent self-fulfilling prophecy, the long-lasting belief of age-related physical vulnerabilities associated with premature cessation of physical activity for "prevention" purposes. However, a lower rate of exercising in aging is associated with cardiovascular disease, metabolic syndrome, cancer, musculoskeletal diseases, mental disorders, and even all-cause mortality (Gennuso et al., 2015; Gorman et al., 2014; de Rezende et al., 2014), reinforcing the initial stereotype of old-frail.

Being physically active, adhering to a healthy diet, and engaging in cognitively stimulating activities are within individuals' control and have been shown to be critical for optimizing chances of healthy cognitive and physical aging (Hertzog et al., 2009). Research is still at its premises to investigate the association between NAS, SPA, and physical activity. In a systematic review by Knight et al. (2021), seven studies included implicit priming or psychological interventions targeting SPA embedded in an exercise session. They generally found benefits for SPA improvement, lower depression levels (Beyer et al., 2019), increased perceived benefits and decreased risks of exercising (Emile et al., 2014), and increased time spent in physical activities (Brothers & Diehl, 2017). Klusmann et al. (2012) were the only ones to have conducted a study to explore the implicit impact of exercise as the sole intervention strategy. The authors found improved age satisfaction for older female adults who followed a six-month exercise intervention three times a week compared to a computer-course intervention program group and a passive non-intervention control group.

In recent years, few studies have investigated the potential benefits of cognitive training on SPA. Cognitive training in working memory, planning, and logic, was found to enhance the subjective perception of cognitive functioning and self-efficacy in daily life in healthy older adults (Goghari & Lawlor-Savage, 2018). These findings were coherent with reasoning training resulting in a less self-report functional decline in older adults (Willis et al., 2006). However, cognitive training is a controversial intervention to improve functioning in non-trained domains. For instance, Bures et al. (2016) found that cognitive training did not improve older adults' well-being compared to leisure activities. To our knowledge, no study has looked at how cognitive training could directly improve SPA and decrease NAS. As this type of training is becoming increasingly popular in the general population, it appears crucial to document its potential value as an intervention for older adults.

Rationale and Objectives of the Studies

Study one: Investigating the effects of negative age stereotypes on older adults' cognitive performance (Julien, A., Kaushal, N., Pothier, K., Dandeneau, S., and Bherer, L.).

NAS activation in the laboratory using blatant or subtle primes is hypothesized as representing a natural environment that older people continually encounter in their interpersonal and institutional milieu. Older adults are believed to undergo everyday NAS primes, which are activated and reinforced, effectively exerting a lasting effect impacting older adults' health and behaviour (Levy, 2009; Levy et al., 2011). This hypothesis brings together stereotype embodiment and stereotype threat theories. However, the unethical nature of intentionally activating NAS in a cognitive assessment is not representative of a realistic clinical setting. Mental health workers know very well the importance of monitoring anxiety levels, regulating emotions and levels of motivation in their patients, and avoiding making comments triggering stress in the examinees.

Furthermore, a realistic clinical milieu also includes normed clinical measures rarely used in research settings, widening the gap between the two areas of activities. This represents a limitation preventing generalizing results from research to clinical settings, not to mention the underlying assumption that clinical measures would be protected from NAS effects. Furthermore, the field has focused primarily on the impact of NAS and verbal memory at the detriment of other forms of memory or cognitive domains, such as processing speed (Horton et al., 2008). Cognitive domains do not work in silos, and exploring a broader range of cognitive functions is necessary to strengthen this generalization from the assessment room to functioning.

The objectives of Study 1 were 1) To investigate the relationship between explicit NAS, implicit NAS, levels of SPA, and older adult's performance on neuropsychological tests employed in clinical settings and 2) to enrich the literature on the relationship of NAS and older adult's performance on visuospatial memory, working memory, and processing speed tasks while controlling for self-perceived competency and value of cognitive performance. The hypotheses are 1) higher implicit/explicit NAS will negatively correlate with cognitive tests scores, whereas better SPA and better self-perceived competency of cognitive performance will correlate positively with cognitive tests scores; 2) Implicit/explicit NAS should predict cognitive tests scores, including negative effect sizes (1 standard deviation increase in NAS should be linked to a lower cognitive score) whereas SPA should predict cognitive scores with positive effect sizes; 3) Explicit and implicit NAS will explain variance in cognitive scores after controlling for demographic measures (age and education), cognitive abilities known as contributing to the cognitive score and self-relevance (self-perceived competency and the degree of which the individual values cognitive performance).

Study two: Exercising your perception of aging: effects of physical and cognitive training on older adults' perception of their own aging (Julien, A, Kaushal, N., Pothier, K., Dandeneau, S., Berryman, N., and Bherer, L.). Satisfaction with individuals' aging has been a core aspect of subjective well-being in older age (Lawton, 1975; Neugarten et al., 1961). However, developing interventions to reduce NAS and improve SPA received little attention in the scientific world (Kleinspehn-Ammerlahn et al., 2008), despite evidence of internalized ageism. Furthermore, many studies aimed at modifying subjective age, conceptualizing that feeling younger means better SPA. Still, only a few aimed to make older adults feel more positive about their age. Being old, feeling old, or looking old should not be the variables targeted by the interventions. Judging and expecting what you can do or not, with the premise that age defines one's possibilities, should be. Among all, interventions working at changing SPA should be sensitive, not perpetuating NAS: younger=good/older=bad.

Finally, studies that have explored situational variables and circumstances in which older people feel more positive about their age are often correlational. They do not allow for causal or directional conclusions (Kotter-Grühn, 2015). In sum, developing interventions to improve SPA requires more attention in the field of research and methodologies to draw firm conclusions about their effectiveness. Furthermore, investigating different types of training may be relevant for the implementation in the community, as various programs may align with individuals' interests and abilities.

The objectives of study 2 were 1) To study the impact of two types of physical training (gross motor abilities and fitness) and cognitive training on NAS endorsement and SPA and 2) To investigate if an increase in SPA covaries with improvement in cognition is attributed to physical and cognitive training. Hypotheses are that 1) SPA will improve and NAS endorsement will decrease among participants, and 2) SPA should improve as a function of better cognition or fitness.

This project aligns with a general movement for better aging for all. It is taking part in a rich literature that has aimed for decades at demonstrating to the community the ravaging effects of ageism on older adults' health and possibilities in society.

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Investigating the Effects of Negative Age Stereotypes on Older Adults' Cognitive Performance

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Abstract

Objective: The literature suggests that negative aging stereotypes (NAS) is negatively related to verbal memory performance in older adults. The first objective was to investigate how NAS and self-perception of aging (SPA) are related to older adults' cognitive performance in standardized testing. The second objective examined whether NAS and SPA are related to the performance on visuospatial memory, working memory, and processing speed. The primary hypothesis was that a higher level of NAS would be linked to lower cognitive scores, whereas better SPA would be linked to higher cognitive scores. NAS would predict performance independently from age, education, cognitive abilities, and perception of competency.

Methods: Participants were adults aged 60 to 87 (*n*=117). Participants completed a cognitive assessment (MoCA, BVMT-R) and measures of implicit (Implicit Association Test-Age) and explicit NAS (Fraboni scale of ageism) and SPA (Attitudes towards own aging) at time one and time two. The battery also included screening tests (MMSE and subtests of the WAIS-IV).

Results: Higher NAS was linked to lower scores in verbal memory, immediate, delayed visuospatial memory, and processing speed. SPA had no relationship with cognitive scores. Hierarchical multiple regression revealed that explicit NAS predicted processing speed after controlling for age, education, cognitive abilities, and perception of competency, and predicted delayed visuospatial memory after accounting for age and education. Implicit NAS predicted verbal memory after accounting for explicit NAS.

Conclusion: Older adults' age-related beliefs about themselves and others significantly influence cognitive performance after accounting for age and cognition-related variables. These findings suggest that NAS should be considered in interpreting cognitive scores.

Keywords: Processing speed, visuospatial memory, negative age stereotypes, clinical neuropsychology, older adults.

Public Significance Statement

Even with the best intentions, warmth, and professionalism, mental health professionals testing older adults' cognition may fail in their clinical interpretation by ignoring the endorsement of patients' negative age stereotypes (NAS). NAS impacts older adults' performance beyond verbal memory and may also decrease visuospatial memory and processing speed. We suggest that NAS should be measured and considered when interpreting older adults' cognitive scores and other psychological states that have been shown to impact cognitive performance, such as anxiety and depressive states.

Investigating the Effects of Negative Age Stereotypes on Older Adult's Cognitive Performance

Physical and cognitive declines in later life can be associated with physiological, sociocultural, and psychosocial factors. Research on patterns of cognitive decrements in later life has tended to focus on biological processes (e.g., Bishop et al., 2010) rather than psychosocial processes such as negative aging stereotypes (NAS) endorsement that may be more amenable to interventions. Stereotyping involves attributing characteristics to a given social group based on a perceived element of truth but spread and generalized to the entire target group with little consideration for individual variabilities. The process of stereotyping offers a structure for supporting biases, discrimination, and power imbalance that older adults experience both at a societal level, in the form of institutionalized ageism, and at the individual level, in the form of the person's thoughts, feelings, and behaviours. Older adults face many NAS: a prevalent one is that as one ages, they should expect cognitive decline that will lead to adverse consequences on daily functioning. Due to the stereotypes that target specific age groups, forgetfulness is often seen as a foreshadowing of dementia. Additionally, reduced processing speed often translates to an individual's decline in comprehension of the world and, therefore, their productivity in society. Consequently, older adults see their life opportunities diminished in many life domains, such as employment (Bowen & Skirbekk, 2013; Roscigno et al., 2007), relationships (Coudin & Alexopoulos, 2010), identity and psychological well-being (Kornadt & Rothermund, 2011), and screening procedures, treatment plan, and healthy lifestyle recommendations (Eymard & Douglas, 2012; Robb et al., 2002). Ageism is believed to cost up to 63 billion dollars to American society (Levy et al., 2020).

Mental health professionals assessing older adults' cognition must consider sleep, stress, motivation, mood, or education variables, as potential factors impacting a patient's performance. These variables offer a context to a given performance and a better understanding of a patient's cognitive functioning; thus, suitable patient care recommendations can be made. Numerous studies have investigated the impact of NAS on cognitive performance. Steele and Aronson (1995) demonstrated that one's group identity, a social context in which a stigma is present and self-relevant, and a setting that can potentially confirm the stereotype could pose a risk to the individual's performance. In aging, having to undergo a cognitive assessment constitutes a similar context of stereotype threat. Only having the administrator say "memory" is enough to activate the NAS and impact performance by motivating the individual to contradict or avoid confirming the stereotype (Rahhal et al., 2001).

Stereotype activation is believed to have roots in internalizing such stereotypes within self-perception. The theory of stereotype embodiment stipulates that stereotypes are internalized at a young age and undergo reinforcement during one's life through observations of how older adults are treated and how age beliefs are expressed in one's social culture. They operate unconsciously, gain salience from self-relevance, and use physiological, behavioural, and psychological pathways (Levy, 2009). Indeed, NAS begin as early as six years old, are internalized during childhood, and are carried throughout adulthood into old age, impacting older adults' behaviour, cognitions, and self-perception (Kwong See & Nicoladis, 2009; Levy, 1996). Self-perception of aging (SPA) translates the degree of satisfaction with one's aging and reflects adaptation to age-related changes (Levy, 2009). In the Embodiment Theory, Levy (2009) proposes that SPA is a "manifestation of internalized age stereotypes" (Sargent-Cox et al., 2013). Internalized age stereotypes have been associated with decrements in a broad range of domains, such as cardiovascular health (Levy et al., 2009), engagement in beneficial health behaviours (Kim et al., 2014; Levy & Myers, 2004; Wurm et al., 2010), general health and longevity (Levy & Myers, 2005; Marchiondo et al., 2017, Sargent-Cox et al., 2012), detrimental brain changes such as the accumulation of plaques and tangles, and reduction in the size of the hippocampus (Levy et al., 2016) and exacerbated stress overtime (Levy & Bavishi, 2018; Levy et al., 2016). Interestingly, a 38-year longitudinal study has investigated the decremental impact of internalized NAS on memory and has shown that decline was not bound by either time or space (laboratory setting), which suggests stereotypes operate through internalization (Levy et al., 2012). Furthermore, societal stereotypes about older adults' competence in various domains tend to be internalized, which can lead to self-fulfilling prophecies: When people endorse NAS at earlier ages, they tend to experience more negative changes in health relative to people endorsing more positive aging stereotypes (Levy, 2009).

Given NAS's prevalence and consequences, research has focused on how these negative beliefs operate from self-concept to behaviour. A meta-analysis by Lamont et al. (2015) reported that culturally shared beliefs that aging leads inescapably to severe cognitive decline and diseases have typically impaired healthy older adults' performance on cognitive tests. Stereotype threat is believed to be a process by which NAS operate (Steele & Aronson, 1995). Stereotype threat occurs when people fear that poor performance on their part will confirm a negative, self-relevant stereotype (Steele, 2010; Steele & Aronson, 1995; Steele & Aronson, 1997). In response to this threat, people tend to underperform compared to their potential, thereby conforming to the stereotype. This was first illustrated by Steele & Aronson (1995). They demonstrated how African American students performed below their potential on the Scholastic Aptitude Test when stereotypes about their intellectual abilities were emphasized. They found that those not exposed to the threat performed at the same level as the Caucasian students. Subsequently, stereotype threat effects have been studied across various stereotyped social groups, including individuals from low socioeconomic status, women, gay men, and older adults (ed. Ayalon & Tesch-Römer, 2018).

In the context of aging, it was experimentally demonstrated that NAS will adversely affect health outcomes and will curtail the cognitive performance of older adults when compared to non-threatened older adults or those with more positive perceptions of aging (Barber et al., 2015; Haslam et al., 2012; Horton et al., 2008; Mazerolle et al., 2016). Lamont et al. (2015) meta-analysis' results showed that age-based stereotypes consistently impair older person's performance across various domains such as physical, skill acquisition, driving, cognitive, and memory performance ($d = 0.28$). More recently, a meta-analysis by Armstrong et al. (2017) reported that stereotypes impact different forms of memory, such as episodic and working memory. The authors found that the effect was only significant when blatant manipulations (salient cues inducing participants' stigma awareness: e.g., reading an article about the adverse of aging on memory before a memory task) were used with episodic memory tasks. However, subtle manipulations (stigma is not directly communicated to participants, e.g., the older participant is asked to complete a memory task in the same room as a younger adult) were enough to impact working memory tasks negatively. However, it was anecdotally reported that neutral priming could negatively impact cognitive performance. For example, in the Hess et al. (2003) study, older participants were primed with negative, positive, and neutral priming methods before a cognitive test session. In the following word memorization test, participants who received negative priming showed a decrease in their cognitive abilities. Interestingly, neutrally primed individuals also exhibited smaller but negative effects on their cognitive skills. Hess et al. hypothesized that this relationship in the control group raises the possibility of the threat being operative without direct exposure to NAS. Under normal testing circumstances, and more so for older adults who value their memory abilities, individuals risk seeing their performance impeded.

However, older adults may be only partially aware of their NAS endorsement, which can be an end process of explicit and implicit cognition. Explicit cognition, such as those measured through self-reports, are attitudes or beliefs available to the conscious mind that people will consider in decision-making and behaviour. However, the validity of measures for socially sensitive topics, for which social desirability may distort self-report responses, can be a limitation when used alone. Implicit cognition includes attitudes and beliefs, unavailable to awareness, that may result from early learnings and past experiences and be nevertheless predictive of behaviour (Greenwald et al., 2009; Nosek et al., 2007). Used concomitantly with self-report, implicit measures could provide a better picture of one's NAS endorsement.

In summary, both explicit and implicit NAS may potentially interfere with older adults' performance at cognitive tests. However, these variables have often been studied separately. Their concomitant inclusion could provide a complete portrait of performance by understanding their respective relationship with cognitive scores once controlled for age, education, cognitive abilities, and perception of competency. The present study included the Implicit Association Test-Age (IAT-Age) for the implicit measure of NAS, the Fraboni Scale of Ageism (FSA) for the explicit measure of NAS (which includes the perception of the in-group and negative aging stereotypes), the Attitude Toward Own Aging subscale (ATOA) from the Philadelphia Geriatric Center Morale Scale for the self-perception of aging and a measure of self-perceived competency and value to perform at cognitive tests. The choice of these measures aligns with the theory of stereotype embodiment, which proposes three ageism predictors that have been involved in decreases in older person's health and performance: age discrimination (detrimental treatment of older persons), negative age stereotypes (negative beliefs about older people in general), and negative self-perception of aging (negative beliefs about one's aging) (Levy et al., 2020).

An essential addition to this project was offering a realistic clinical setting that would promote performance and respect clinicians' professional ethics. This included a consideration of the physical milieu, ethical therapeutic relationship, and the use of clinically standardized measures of cognition. Researchers hypothesize that the activation of NAS in the laboratory represents a natural milieu in which older adults continually encounter in their interpersonal and institutional world everyday primes which are activated and reinforced, effectively exerting a lasting effect impacting older adults' health and behaviour (Levy, 2009; Levy et al., 2011). This hypothesis brings together the theories of stereotype embodiment and stereotype threat; however, bluntly or subtly activating NAS does not represent a realistic clinical setting due to the manipulation, which is clinically unethical. Mental health professionals would avoid making comments that may trigger stress in the examinee. It is best practice to monitor anxiety, emotional regulation, and unconstructive behaviours to obtain a performance representative of the examinee's cognitive abilities. Just as Hess et al. (2003) illustrated, real-world testing situations, such as testing in a clinic, may induce a stereotype threat in and of itself without having to stage any particular manipulation (Spencer et al., 2016). A realistic clinical setting also includes normed clinical measures that research protocols rarely use. This limitation can complicate the generalization of research to clinical settings, not to mention the underlying assumptions that clinical measures could be protected from NAS effects. Another weakness in the field is the attention that verbal memory receives at the expense of other cognitive domains, such as other forms of memory and processing speed (Horton et al., 2008). Enriching findings with a broader range of cognitive functions is necessary to strengthen this generalization from the assessment room to functioning. Altogether, the employment of nonclinical measures, narrow cognitive domains investigated, and clinically unethical behaviours prevent the practical application of this rich literature that has aimed for decades at demonstrating to mental health professionals the importance of including NAS in their interpretation of their patient's cognitive results.

The Present Study

The objectives are 1) To study the relationship between implicit NAS, explicit NAS, levels of SPA, and older adult's performance on neuropsychological tests employed in clinical settings and 2) to enrich the knowledge of the relationship of NAS and older adult's performance on visuospatial memory, working memory, and processing speed tasks while controlling for self-perceived competency and value of cognitive performance. Hypotheses are that 1) higher implicit/explicit NAS will negatively correlate with cognitive tests scores, whereas better SPA and better self-perceived competency of cognitive performance will correlate positively with cognitive tests scores; 2) Implicit/explicit NAS should predict cognitive tests scores, including negative effect sizes (1 standard deviation increase in NAS should be linked to a lower cognitive score) whereas SPA should predict cognitive scores with positive effect sizes; 3) Explicit and implicit NAS will explain variance in cognitive scores after controlling for demographic measures (age and education), cognitive abilities known as contributing to the cognitive score and self-relevance (self-perceived competency and the degree of which the individual values cognitive performance).

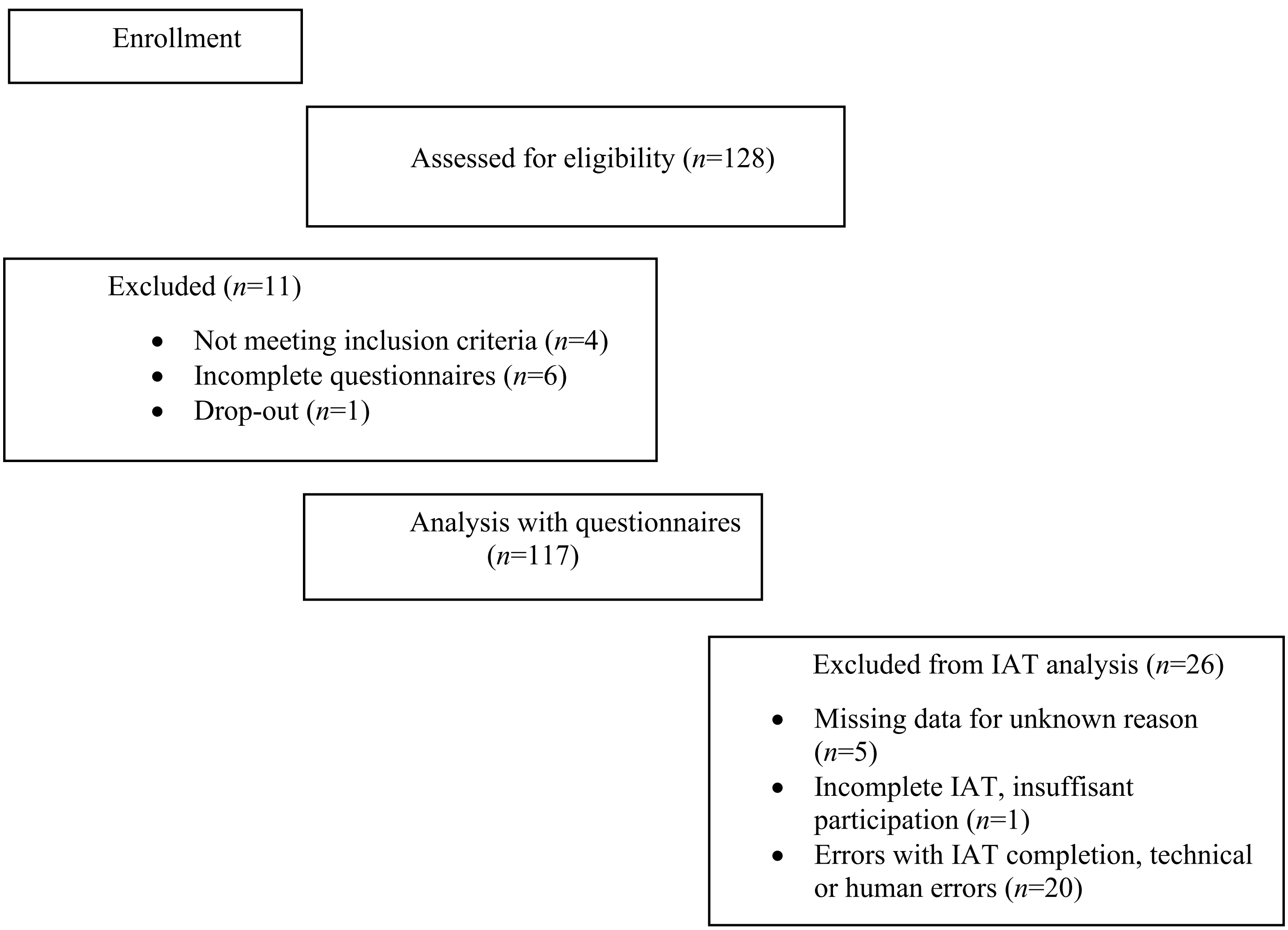
Method

Study Design and Participants

This study is a subproject of a major randomized controlled trial study primarily designed to determine the effects of 12-week exercise interventions on health and mobility in aging (Pothier et al., 2021). Sedentary healthy adults (60+) were recruited in the community from Montreal and its surroundings through magazines and newspapers (e.g., Le Bel Age). Participants were screened for signs of dementia (score <26 on the Mini-Mental State Examination (Folstein et al., 1975) or depression (score > 11 on the Geriatric Depression Scale (Yesavage et al., 1982), in addition to demonstrating any physical limitations for exercising as assessed by a geriatrician at pre-testing. In this 1-hour appointment, the following were evaluated: their general physical condition; the presence of chronic diseases; abilities to complete activities of daily living; medication use; cognitive symptoms, and mobility. Measurements of their body weight, height, blood pressure, reflexes, coordination, and proprioception were also completed. Finally, a global evaluation of their frailty was also assessed to validate their inclusion in the study.

Furthermore, participants included had to be non-smokers for the past five years, right-handed, have a moderate consumption of alcohol (≤ two glasses per day), have no history of alcohol or drug abuse, have no current somatic or psychiatric disorder, and have no surgery or other medical intervention which involved a general anesthetic in the past six months, unstable medical problems (unstable cardiorespiratory illness, cardiac troubles, palpitations) in the year preceding the protocol, no abnormal body mass index (<18.5 or >29.9 kg/m2) according to the geriatrician's recommendations, no significant and uncorrected perceptual limitations, no severe tremors or involuntary movements, no history of a severe injury to any upper limb currently affecting mobility, no severe or recurrent epilepsy, no diagnostic or treatment for severe depression in the past five years, not undergoing any hormone therapy treatment and no participation in an intervention study or program over the last year. Participants who met these criteria were considered going through a normal developmental stage. This was an essential part of the sample selection process, as NAS would be less likely to be endorsed in interaction with objective symptoms characterizing abnormal aging.

This study was conducted in accordance with the Declaration of Helsinki. It was approved by the Concordia University Human Research Ethics Committee and the Research Center of the Institut Universitaire de Geriatrie de Montreal. Written informed consent was obtained from all individual participants included in the study. However, participants were blind to the subproject goals.



Analysis with IAT (*n*=98)

*Diagnosed Brain tumour after day 1 of pre-test (*n*=1)
Abnormal Vo2 Max (*n*=1)
Abnormal MoCA/MMSE (*n*=2)

Measures

Participants were invited to a one-hour session in which they completed neuropsychological testing. The Implicit Association Test-Ageism (IAT-Age) was administered after the battery of cognitive measures. Questionnaires were explained after the IAT and were completed at home during the following week without the presence of researchers.

All participants completed measures of neuropsychology battery targeting specific functions (memory, attention, executive functions, abstract verbal reasoning, and processing speed) commonly used in clinical work with older adults. The session took place one week apart from the day they came to the laboratory and met members of the research team to sign the consent form. This process was meant to familiarize participants with the setting in which they would be tested. Administrators were graduate students who received formal training from a neuropsychologist and were prescribed to use the standardized verbatim in administering the tests. Testing was held individually in a comfortable room. Administrators welcomed each participant, presented themselves (name and function in the project), and did a brief introduction before starting by saying that they (the participant) would be completing some pencil/paper exercise for the next hour. Participants were asked to give their best while being told that some questions would appear easy to them and others more difficult, which was normal. All cognitive testing was held in the morning to early afternoon between 8:am and 1:pm. Of importance, test instructions did not explicitly mention that memory would be measured.

This protocol followed recommendations for a favourable testing environment (Sindi et al., 2013): 1) Testing location: The testing environment was known to participants as it was the second day of testing, and they all had to come in for the 1st day of evaluation 2) Time of testing: Older participants perform better between 8:am and 12: pm; 3) Task instruction: We avoided terms such as "memory" or "memorizing" to decrease the emphasis on the memory component of the task while respecting the standardized verbatim of the tests (which do not include these terms). Sindi et al. (2013) also recommend that the age of the clinician or research assistant should be like that of the participants, as a younger adult examiner can lead to a more significant stereotype threat in older adults and consequently to an increase in stress. Although this element is relevant, it is hardly feasible as age is not a variable easily manipulated in a natural clinical setting. For this reason, we did not follow that recommendation, although all the examiners are trained to conduct assessments limiting external factors that could damage older adults' performance.

Measures of negative aging stereotypes (NAS) and self-perception of aging. An explicit measure of ageism (The Fraboni Scale of Ageism), an implicit measure of ageism (IAT-Age), and a measure of attitudes toward own aging (A subscale of the Philadelphia Geriatric Center Morale Scale) were employed. A measure of self-perception in cognitive performance was also included for measuring individual self-relevance and level of importance to perform well at cognitive tasks.

The fraboni scale of ageism (FSA; Fraboni et al., 1990). The FSA construct is derived from Butler's (1978) definition of ageism. It is a validated measure of external ageism designed to assess both cognitive and affective components of ageism. The participants answer 29 questions on a 4-point Likert Scale, going from "strongly disagree" to "strongly agree." Higher scores mean higher ageism. Fraboni et al. (1990) found FSA scores to have adequate internal consistency reliability with a Cronbach's alpha coefficient of .86 and revealed a lack of influence from social desirability. This questionnaire produces a global score for ageism and three individual scores for levels of prejudice: Discrimination (discriminatory opinions regarding political rights, segregation, and activities of older adults, e.g., "Most old people should not be trusted to take care of infants"), Avoidance (withdrawal from social contact with older persons, e.g., "I sometimes avoid eye contact with old people when I see them") and Antilocution (antagonism and antipathy fuelled by misconceptions, misinformation, or myths about older persons, e.g., "Many old people just live in the past"). Cronbach's coefficient alpha reliabilities of the Antilocution, Avoidance and Discrimination subscales were reported as .76, .77, and .65, respectively. A more recent study by Credé et al. (2003) revealed an alpha reliability estimates of these subscales were .75, .61, and .77, respectively.

Implicit association test-ageism (IAT; Greenwald, McGhee, & Schwartz, 1998). Implicit social cognition, including attitudes and stereotypes, often operates automatically and without awareness to affect judgments and behaviours (Greenwald & Banaji, 1995). The IAT has been largely used to measure automatic attitudes, stereotypes, and identity in various domains, including age (Greenwald & Nosek, 2001). The IAT has often correlated only weakly with self-report measures of the same construct, supporting that IAT assesses processes that are often distinct from the corresponding constructs measured by self-report (Dasgupta & Greenwald, 2001; Greenwald & Farnham, 2000; Greenwald & Nosek, 2001; Lee Hummert et al., 2002). The fundamental assumption of the IAT-Age is that judgments congruent with participants' implicit associations of the older adult's category with an evaluative category, such as unpleasant, will be easier and made more quickly than those that are incongruent, such as young and unpleasant.

In other words, the IAT relies on a response latency indicator obtained in pairing the attitude object (a social group such as old-young) with an evaluative dimension (good-bad). A computerized version was used in which the participant was presented with photographs of young and old adults (at the center of the screen) one at a time and paired each picture as quickly as possible with an evaluative word (pleasant-unpleasant). The speed at which this pairing was completed in the congruent association compared to the incongruent one was interpreted as a measure of the strength of an implicit association (attitude). Greenwald et al. (2009) meta-analysis found an average $r = .274$ for predicting behavioral, judgment, and physiological measures by IAT measures. This meta-analysis also revealed that age, ethnicity, and weight were group categories in which the predictive validity of IAT significantly exceeded that of self-report measures. The IAT was believed to be a significant addition to the measures kit in this study since implicit dimensions assessed by the IAT may be more strongly linked to behaviour than the dimension targeted by self-report attitudes scales.

Attitudes toward own aging (ATOA); Subscale of the Philadelphia geriatric center morale scale (Lawton, 1975). The Philadelphia Geriatric Center Morale Scale is a multidimensional approach to assessing the psychological state of older people (Lawton, 1975). The subscale assessing the Attitudes Toward Own Aging (ATOA) was used, with items related to the older person's experiences of their aging process. This measure captures the individual's perception of the changes in their life and asks for an evaluation of those changes. Respondents are asked to indicate yes or no to six statements (e.g., "As you get older, you are less useful," "I am as happy now as when I was younger"). Higher scores mean a better perception of own aging. Internal consistency was found to have an alpha of 0.81 for this subscale.

Measures of self-perception in cognitive performance. This questionnaire was adapted from an initially designed version to measure adolescents' achievement task values and expectancy-related beliefs for mathematic performance (Eccles & Wigfield, 1995). All participants completed a questionnaire at home measuring their expectations about their performance at cognitive tests and the extent to which they valued their performance. They answered 10 questions on a 7-point Likert scale. The total score is the product of the 10 questions mean and relates to the degree of motivation to perform well at cognitive testing.

Of interest in our study were the subscales of Value and Competency that are extracted by averaging selected items together. Value is the average of five questions: "Is the amount of effort it will take to do well on the most difficult memory and attentional tasks worthwhile to you?" (1 being Not very worthwhile and 7 Very worthwhile), "How is it important to you to get good results on memory and attentional tasks?" (1 being Not at all important and 7 Very Important), "I feel that it is important being good at completing memory and attentional tasks" (1 being Not at all important and 7 Very Important), " In general I find participating in memory and attentional testing…(1 being Very boring and 7 Very interesting) and "How much do you like doing memory and attentional testing?" (1 being Not very much and 7 Very much). Competency is obtained by averaging five questions: ("If you were to order all the participants in this research project from the worst to the best in memory and attentional tasks, where would you put yourself?" (1 being The worst and 7 The best), "Compared to other participants, how well do you expect to do on memory and attentional tasks? (1 being Much worse than the other participants and 7 being Much better than the other participants), "How good are you at memory and attentional tasks? (1 being Not at all good and 7 Very good)," How have you been doing so far in your life with memory and attentional tasks? (1 being Very poorly and 7 Very well), "How well will you do on the memory and attentional tasks in this research project?" (1 being Very poorly and 7 Very well). Of note, in questions involving a comparison component, participants were aware that "other participants" were aged 60 and over.

Cognitive measures. The clinical tests consisted in two tests routinely used for cognitive screening, and tests in the domains of visuospatial memory, working memory, processing speed and abstract verbal reasoning. They were chosen for their frequent usage in clinical settings and their specific cognitive domain focus. Participants completed the following neuropsychological tests in the presented order:

Montreal cognitive assessment (MoCA) (Nasreddine et al., 2005): This is a cognitive screening test designed to assist health professionals in detecting mild cognitive impairment and Alzheimer's disease. It contains subtests assessing orientation, memory, executive function/visuospatial ability, language abilities and naming, abstraction, and attention. It also includes a clock-drawing test. The cut-off considered normal is a score of 26/30. The total score is adjusted for low education by adding one point for individuals with 12 years of education and lower. The MoCA has shown a sensitivity of 90% in a clinical population of MCI subjects and a specificity of 87% (Nasreddine et al., 2005).

Mini-mental state examination (MMSE) (Folstein et al., 1975): This test measures cognitive function by examining orientation, word recall, language abilities, attention and calculation, and visuospatial memory. The cut-off considered normal is 26. Using this cutoff, the MMSE shown a sensitivity of 18% in a clinical population of MCI subjects and a specificity of 100% (Nasreddine et al., 2005).

The brief visuospatial memory test-revised (BVMT-R; Benedict et al., 1996). This test measures visual learning and memory using a multiple-trial learning paradigm. It requires participants to learn and retain six forms that yield immediate recall, delayed recall, and recognition measures. The participant is shown an 8 X 11-inch plate containing six simple geometric visual designs in a 2 X 3 matrix. The matrix is presented for 10 seconds for three learning trials. After each 10 seconds presentation, the participant is asked to reproduce as many designs as possible on a blank sheet of paper in the location they appeared on display. There is no time limit for recall, and the participant is encouraged to improve their performance at each additional trial. After a 25 minutes delay in which other tests were administered (see list above), the patient is asked to reproduce the design one more time. The participants were not told they should remember the figures. This delayed recall trial is followed by a recognition trial in which the individual is shown 12 designs, each printed on a 3 X 5-inch card, one at a time. The participant is asked to answer "yes" to those designs that were part of the matrix and "no" to those which were never presented. The recognition task includes six targets and six nontargets.

Age was found to moderately correlate (r = -.44 to -.50) with the results of this test (Benedict et al., 1996). Correlations between age and recognition performance were not significant. On average, age accounted for about 11% of the variance in BVMT-R scores (Benedict, 1997). Gender was not found to influence most aspects of recall and recognition performance (Benedict, 1997). Regarding education, its relationship as a predictor of BVMT-R scores has led to mixed results. Benedict et al. (1996) found that correlations were weak (r = ‹ .20), and the standard T-scores generated for the test only corrected for age. However, education was found to be a significant predictor of BVMT-R scores in subsequent studies (Norman et al., 2011; Wit et al., 2017). Furthermore, Petersen (2004) recommended considering the presence of memory impairment when an individual obtained memory scores that were lower than expected based on age and education without providing clear cut-off scores. In summary, although education was not formally included in Benedict's (1997) norms, education has been found to have a significant role in memory performance. Some studies have found significant results, specifically with the BVMT-R. The reliability coefficient varies from marginal to high, ranging from .60 for Trial 1 to .84 for Trial 3. The reliability coefficient for the total recall score is .80 (Benedict, 1997).

Selected subtests Wechsler adult intelligence scale fourth edition (WAIS-IV) Wechsler et al., 2008. The WAIS is the most frequently used measure of intelligence for children, adolescents, and adults (Lichtenberger & Kaufman, 2009). The WAIS-IV was normed on 2,200 people aged 16 to 90, from which 600 were adults over 65 (M= 75.68, SD= 7.68). For people 65 years of age and older, reliability coefficients for the WAIS-IV subtests range from r = .78 to r = .98 (Wechsler, 2008). For WAIS-III, there were few differences between younger and older people in most tests assessing verbal abilities, although large differences were found in nonverbal abilities (Strauss et al., 2006). Subtests measuring information processing speed showed the greatest difference with increasing age (Heaton et al., 2003; Ryan et al., 2000).

Digit Span forward/backward. This subtest is part of the Working Memory Index. It requires attentional/short-term memory abilities (forward condition) and the ability to manipulate information mentally (backward condition). Participants are asked to repeat number sequences in the same order as presented. In the backward condition, participants repeat the sequences in reverse order.

Similarities. This is a measure of abstract verbal reasoning and semantic knowledge and one of the subtests composing the verbal comprehension index. The participant is asked to describe how two objects are similar conceptually.

Coding. This subtest is a primary measure of information processing speed and efficiency. It is a complex task requiring multiple cognitive abilities, including concentration, attention, cognitive flexibility, visual scanning, and motor coordination (Joy et al., 2003). The participant is initially shown a key containing the numbers one to nine. Under each number, there is a corresponding geometric symbol. The participant is then shown a series of boxes containing numbers in the top boxes and blank boxes below. After a short practice trial, they are asked to copy the corresponding symbols under each number. Participants are told to go as fast as they can without making mistakes. The raw score is the number of correct items within the prescribed time limit (120 seconds).

Transparency and Openness

We have reported the process by which we determined our sample and described all data exclusions, manipulations, and measures in this study. Our analysis only included participants that met inclusion criteria and were free from any exclusion criteria. Deidentified data and analysis can be made available upon request. Stimulus materials and protocols are copyright protected and cannot be provided.

Statistical Methods

Analyses were conducted with SPSS version 20. Normality was investigated by the evaluation of the Q-Q plots and histograms. Outliers was calculated with the interquartile range rule using a the 2.2 factor as suggested by Hoaglin and Iglewicz (1987). Two participants who did not meet these upper or lower limits were excluded from the analysis. Missing values representing 1.65% of the data were replaced by the median.

The primary hypotheses were investigated by conducting a series of linear regressions to test if determinants of aging, which included explicit NAS, implicit NAS, and attitudes towards own aging, would predict each cognition score. Next, value and competency were tested to verify if they predicted cognition scores. The regression models placed the determinants of aging, value, and competency as independent variables. The dependent variables were MMSE and MoCA scores, MoCA memory subtest, BVMT-R Immediate, Delayed, and Recognition conditions, coding, similarities, and digit span forward/backward.

The second hypothesis used hierarchical linear regressions with centered variables to further investigate significant interactions. Eight models were conducted with each cognitive test under investigation as the dependent variable (MoCA, MoCA memory, BVMT-R immediate, delayed, and recognition, and coding). In step one of each model, we included theoretically and statistically significant predictors (demographics, cognitive abilities and value, and competency); in step two, we included the NAS predictor; and in step 3, we included a mean-centered term to test the interaction between NAS and the three factors Age, ATOA and Competency (Table 1). We used MoCA scores adjusted for education ≥12. For analysis involving IAT, we modified all the variables in the model in z scores since the IAT provides a standardized score.

Results

Recruitment yielded 117 participants (32 men, 85 women, 85% born in Canada, 15% born in Europe, the United States, the Caribbean, the Middle East, Asia, Africa and South America) for the analysis. The sample's age ranged from 60 to 87 years (M= 70.16, SD= 5.82), and the education ranged from seven to 27 years (M=16, SD=3.63). The data was collected at the Perform Centre (Concordia University) and the Centre de recherche de l'Institut Universitaire de gériatrie de Montréal between 2016 and 2018.

Hypothesis testing

Correlations. To test the first hypothesis, we conducted correlations between FSA, IAT, ATOA, Competence, Value and cognitive scores. Demographic variables were also included to prepare the regression models. The bivariate matrix showed that FSA negatively correlated with MoCA memory (r= -.187, p=.044), BVMTR Immediate (r= -.190, p=.040) and Delayed recall (r= -.219, p=.017), as well as with coding (r= -.280, p=.002). The IAT-Age negatively correlated with MoCA (r= -.209, p=.039) and MoCA memory (r= -.231, p=.022). Age negatively correlated with MMSE (r= -.209, p= .023), BVMTR immediate (r= -.229, p=.013), Delayed (r= -.244, p=.008) and Coding (r= -.226, p=.014), whereas education had a significant positive correlation with BVMT-R Delayed (r=.208, p=.025) and Similarities (r=.524, p=.000).

The ATOA did not correlate with BVMT-R Immediate, Delayed and Recognitions, Coding, Digit Span Total, and Similarities.

Regressions. To test the second hypothesis, simple linear regressions were conducted with FSA, IAT, Competency, Value, and demographics as predictors. The analyses revealed that FSA predicted MoCA memory (β=-.187, p=.044), BVMT-R scores in both Immediate (β=-.19, p=.040) and Delayed (β=-.219, p=.017) modalities and Coding (β=-.280, p=.002). IAT predicted MoCA (β =-.209, p=.039) and MoCA memory (β =-.231, p=.022). Competency predicted Coding scores (β=.213, p=.021), whereas Value (β=.331, p=.000) predicted BVMT-R Recognition score. Age was found to predict BVMT-R Immediate (β=-.229, p=.013), Delayed (β=-.244, p=.008), and Coding (β=-.226, p=.014) scores, whereas education predicted BVMT-R Delayed (β=.208, p=.025) and Similarities (β=.524, p=.000) scores.

To test the third hypothesis, models of hierarchical multiple regression were conducted. The analyses revealed that FSA scores still significantly predicted Coding scores (R^2=.209, F=.033, β=-.19, p=.000) after accounting for age, education, and individual scores at BVMT-R Immediate, Digit Span Total, and Competency. FSA score predicted coding independently from Age and Competency. FSA predicted BVMTR-Delayed (R^2=.142, F=.032, β=-.19, p=.001) after accounting for age and education and independently from age. Similar results were obtained independently from ATOA (R^2=.169, F=.021, β=-.20, p=.000). However, FSA was no longer found to significantly change the F value once Coding was included in these two models. Furthermore, FSA did not significantly predict scores in the BVMT-R Immediate modality, with age still explaining mainly the variance in the model (R^2=.097, F=.009, β=-.19, p=.009). IAT significantly predicted MoCA memory after accounting for FSA (R^2=.082, F=.025, β=-.225, p=.017). Lastly, Value was found to significantly explain variance in BVMT-R Recognition once BVMT-R Delayed recall has been accounted for (R^2=.161, F=.000, β=.33, p=.001).

Table 1. Demographic *N*=117

Characteristics	
Age	70.16 (5.82)
Education	16 (3.63)
Female (%)	72.65
Born in Canada (%)	85

Table 2. Cognitive measures results

Measures	*n*=117	mean	standard deviation
MMSE		28.39	1.24
MoCA Standard			
Memory		3.68	1.31
Total		26.39	2.37
BVMT-R			
immediate recall		15,81	7.33
delayed recall		6.62	2.89
WAIS-IV			
Digit span forward		9.24	2.12
Digit span backward		7.55	2.27

Digit span total	16.79	3.99
Similarities	23.09	5.6
Coding	59.33	13.11

MMSE= mini-mental state examination; MoCA Standard= Montreal cognitive assessment adjusted for education; BVMT-R=Brief visuospatial memory test-revised; WAIS-IV=Wechsler adult intelligence scale 4th edition

Table 3. Negative aging stereotypes measures

Measures	*n*=	mean	standard deviation
FSA	117	54.09	8.96
ATOA	117	4.4	1.62
IAT-Age (z score)	98	.73	.47
Motivation cognition total	117	5.35	.68
Motivation physical total	117	5.37	.92

FSA=Fraboni scale of ageism; ATOA=Attitudes towards own aging; IAT-Age=Implicit association test-Age

Table 4

Hierarchical multiple regressions models

Independent Variables	Dependent variable	β	*t*	p-value
Model 1				
Step 1				
Age	Coding	-.20	-2.22	.028*
Education		.89	1.028	.306
Digit Span Total		.16	2.024	.080
BVMT-R Immediate		.11	1.164	.247
Competency		.19	2.102	.038*
Step 1 R^2	.176			
Step 1 *F* variation	4.739			
Step 1 *F* variation sig.	.001*			
Step 1 Model	.001*			
Step 2				
FSA		-.19	-2.175	.032*
Step 2 R^2	.209			
Step 2 *F* variation	4.643			

Step 2 *F* variation sig.	.033*			
Step 2 Model	.000*			
Step 3				
FSA X Age		-.035	-.406	.685
Step 3 *F* variation	.165			
Step 3 *F* variation sig.	.685			
Step 3 Model	.000*			
Total R^2	.210			
n	117			
Model 2				
Step 1				
Age	BVMT-R Delayed	-.23	-2.609	.010*
Education		.22	2.518	.013*
Step 1 R^2	.107			
Step 1 *F* variation	6.796			
Step 1 *F* variation sig.	.002*			
Step 1 Model	.002*			
Step 2				
FSA		-.19	-2.083	.039*
Step 2 R^2	.142			
Step 2 *F* variation	4.691			
Step 2 *F* variation sig.	.032*			
Step 2 Model	.001*			
Step 3				
FSA X Age		.58	.656	.513
Step 3 *F* variation	.430			
Step 3 *F* variation sig.	.513			
Step 3 Model	.001*			
Total R^2	.145			

n	117				
Model 3					
Step 1					
Age	BVMT-R Delayed	-1.9	-2.140	.035*	
Education		.19	2.217	.029*	
Coding		.213	2.307	.023*	
Step 1 R^2	.163				
Step 1 *F* variation	7.332				
Step 1 *F* variation sig.	.000*				
Step 1 Model	.000*				
Step 2					
FSA		-.130	-1.438	.153	
Step 2 R^2	.180				
Step 2 *F* variation	2.352				
Step 2 *F* variation sig.	.128				
Step 2 Model	.000*				
Step 3					
FSA X Age		.067	.771	.442	
Step 3 *F* variation	.594				
Step 3 *F* variation sig.	.442				
Step 3 Model	.000*				
Total R^2	.185				
n	117				
Model 4					
Step 1					
Age	BVMT-R immediate		-.219	-2.416	.017*
Education			.125	1.395	.166
Step 1 R^2	.067				
Step 1 *F* variation	4.088				

Step 1 *F* variation sig.	.019*			
Step 1 Model	.019*			
Step 2				
FSA		-.153	-1.683	.095
Step 2 R^2	.093			
Step 2 *F* variation	3.227			
Step 2 *F* variation sig.	.075			
Step 2 Model	.011*			
Step 3				
FSA X Age		.094	1.041	.30
Step 3 *F* variation	1.083			
Step 3 *F* variation sig.	.30			
Step 3 Model	.017*			
Total R^2	.102			
n	117			

Model 5

Step 1				
Age	BVMT-R Immediate	-.190	-2.063	.041*
Education		.105	1.167	.246
Coding		.152	1.589	.115
Step 1 R^2	.097			
Step 1 *F* variation	4.061			
Step 1 *F* variation sig.	.009*			
Step 1 Model	.009*			
Step 2				
FSA		-.114	-1.214	.227
Step 2 R^2	.112			
Step 2 *F* variation	1.802			
Step 2 *F* variation sig.	.182			
Step 2 Model	.010*			
Step 3				
FSA X Age		.100	1.118	.266
Step 3 *F* variation	1.250			
Step 3 *F* variation sig.	.266			
Step 3 Model	.012*			
Total R^2	.121			

n	117				
Model 6					
Step 1					
BVMT-R Delayed	BVMT-R Recognition		.35	4.213	.000*
Step 1 R^2	.133				
Step 1 *F* variation	17.597				
Step 1 *F* variation sig.	.000*				
Step 1 Model	.002*				
Step 2					
Value			.31	3.779	.000*
Step 2 F variation	14.281				
Step 2 *F* variation sig.	.000*				
Step 2 Model	.000*				
Total R^2	.229				
n	117				

Model 7					
Step 1					
*Z*BVMT-R delayed	*Z*MoCA memory		.190	1.824	.71
*Z*DS total			.009	.086	.93
*Z*Coding			.202	1.979	.05*
*Z*Similarities			-.127	-1.205	.23
Step 1 R^2	.103				
Step 1 *F* variation	2.666				
Step 1 *F* variation sig.	.037*				
Step 1 Model	.037*				
Step 2					
IAT			-.212	-2.187	.031*
Step 2 *F* variation	4.781				

Step 2 *F* variation sig.	.031*			
Step 2 Model	.011*			
Total R^2	.147			
n	98			
Model 8				
Step 1				
Z FSA	*Z*MoCA memory	-.17	-1.732	.79
Step 1 R^2	.032			
Step 1 *F* variation	3.157			
Step 1 *F* variation sig.	.079			
Step 1 Model	.079			
Step 2				
IAT		-.23	-2.285	.17*
Step 2 *F* variation	5.222			
Step 2 *F* variation sig.	.025*			
Step 2 Model	.017*			
Total R^2	.082			
n	98			

Note: *β* is the standardized coefficient; Z Fraboni and ZMoCA memory are in standardized scores**. Abbreviations:** Ageism, Fraboni Scale of Ageism; BVMT-R, Brief Visuospatial Memory Test-Revised

Discussion

The first objective of the present study was to investigate how implicit and explicit NAS (IAT, FSA) endorsement and self-perception of aging (ATOA) relate to older adults' performance on neuropsychological tests used in clinical settings. We used an optimal setting for recommendations of a favourable testing environment (Sindi et al. (2013) for evaluating older adults' cognition. The second objective was to enrich our knowledge about the relationship between NAS and visuospatial memory, working memory, and processing speed while controlling for self-perceived competency and value. Hypotheses were that 1) higher implicit/explicit NAS would negatively correlate with cognitive tests scores, whereas better self-perception of aging and better self-perceived competency of cognitive performance would correlate positively with cognitive tests scores, 2) Implicit/explicit NAS would predict cognitive tests scores, including negative effect sizes, whereas self-perception of aging would predict cognitive scores with positive effect sizes 3) Explicit NAS would explain variance in cognitive scores after controlling for demographic measures (age and education), cognitive abilities known as contributing to the cognitive score and self-relevance (value and competency).

Confirming the first hypothesis, higher levels of explicit NAS (FAS) were linked to lower scores on the memory subtest of the MoCA, BVMT-R immediate and delayed recall, and Coding. Higher levels of implicit NAS (IAT) were linked to lower MoCA scores and the memory subtest of the MoCA. However, self-perception of aging (ATOA) did not correlate with cognitive scores. In line with the second and third hypotheses, explicit NAS predicted BVMT-R delayed recall and Coding after controlling for age, education, and other cognitive predictors underlying the cognitive domain of interest. However, once processing speed was included in the model, explicit NAS no longer significantly predicted visuospatial memory. This is coherent with Tam and Schmitter-Edgecombe (2013), who showed that processing speed was a unique predictor of BVMT-R learning and memory performance compared to executive functions after controlling for age and visuoconstructive abilities. Explicit NAS predicted BVMT-R delayed recall and Coding scores independently from age and self-perception of aging. However, explicit NAS had no relationship with BVMT-R recognition, digit span, and similarities scores.

Finally, implicit NAS (IAT) predicted scores at MoCA and MoCA Memory. For the latter, this prediction was found to be significant once controlled for visuospatial memory (BVMT-R delayed), auditory attention and working memory (Digit Span), processing speed (Coding) and abstract verbal reasoning (Similarities). Interestingly, a different model suggests that implicit NAS predicts scores at MoCA memory when controlling for explicit NAS. Regarding self-relevance, only perceived competency predicted scores at Coding and Value predicted scores at BVMT-R Recognition independently from BVMT-R delayed recall score. It has been suggested that the recognition condition of a visual memory task relies on motivational processes or impairment in disengaging-engaging attention (Iachini et al., 2009). Qualitatively, participants generally found it highly valuable to perform well at cognitive tests while at the same time expecting to perform poorly at them.

The effect sizes obtained from the multiple regressions suggest a small relationship between the determinants of aging and cognitive scores. In the literature, effect sizes reported are drawn from designs exploring the effect of stereotype threat, which involved stereotypes activation with participants. These studies yielded a small effect size in the domain of episodic memory (d=0.25) and working memory (d=0.37) (Armstrong et al., 2017). This raised further questions on the necessity to trigger a stereotype deliberately in the room to see an older person being impaired.

In contradiction with our hypothesis, self-perception of aging (ATOA) did not show any relationship with the dependent variables. In the literature, the interaction between explicit NAS, self-perception, and self-relevance is not entirely understood and led to different results. Yet, it has been generally demonstrated that older adults seem to be more susceptible to the effects of stereotypes on memory when they value memory abilities (Hess et al., 2003), along with higher education (Hess et al., 2009) and stigma consciousness (Hess et al., 2009; Kang & Chasteen, 2009). However, in our study, explicit NAS, which reveals one's stigma awareness, was found to transcend all these other contributors. Our results likely support the idea that these boundaries are not distinct, as what you think of your group may be internalized and activated in situations where the stereotype is present. This could also mean that self-perception could protect health a long way by promoting healthy behaviors. Still, when older adults face a stereotype relevant to the group, self-perception is no longer protective of performance.

Spencer et al. (2016) propose that stereotype threat arises from any situational cue indicating that an individual is at risk of being judged negatively, considering a stereotype regarding one of their social identities. Consequent to earlier findings on stress induced by testing (Sindi et al., 2013), a neuropsychological testing room aiming at testing older adults' cognition is likely to represent such a setting with situational cues inherent to the testing process, even in a testing condition favouring older adults. Furthermore, people tend to be highly sensitive to signals indicating that one of their social identities is at risk of being devalued (Purdie-Vaughns et al., 2008; Wout et al., 2009), and therefore cues do not need to be blatant to trigger stereotype threat in targeted groups. Both blatant and subtle cues can harm performance (Lamont et al., 2015). Targeted groups aware of a given stereotype, regardless of whether they believe it, are likely to become highly skilled at reading situations they encounter to determine whether the stereotype may be applied to them in that setting, which in return will impact their performance (Spencer et al., 2016). This may explain our results, as explicit NAS showed that participants were aware of their in-group stigma and that awareness was sufficient to impair performance regardless of how positive they perceived themselves or how optimistic they were about their cognitive performance.

Taken broadly, the results from this study are coherent with the literature on NAS and memory performance in older adults (see Armstrong et al., 2016; Horton et al., 2008; Lamont et al., 2015; Meisner, 2012; Westerhof et al., 2014 for review and meta-analysis). However, most of these studies included nonclinical verbal memory tasks, for which it is well established that they are sensitive to NAS activation. To our knowledge, few studies have looked at visuospatial memory abilities and used a clinically normed test. Our results on visuospatial memory have mixed consistency with findings from Meneghetti et al. (2015), who found that age was the best predictor of performance in spatial recall tasks compared to their perceived stereotype threat measure. Our results suggest that explicit NAS endorsement predicted visuospatial performance beyond age. This is coherent with Meneghetti et al.'s findings (2015) that perceived stereotype threat influenced performance when the spatial task involved recalling information that was the same format and perspective as in the encoding phase (e.g., studying a map and drawing the map from memory), which are the conditions of the BVMT-R test.

To our knowledge, no studies have looked at the relationship between NAS and processing speed abilities as directly measured by clinical tests. It is assumed that older adults observe a slowing down in information processing due to their age. However, stereotype threat is believed to negatively impact controlled processing due to heightened physiological response, increased task monitoring, and attempts to suppress negative emotion (Schmader et al., 2008). Our preliminary results on processing speed are consistent with this. Processing speed, possibly mediated by NAS, should be the focus of future studies as slower processing may be a major underlying contributor to decrements in working memory, memory, and learning. Future studies could focus on why NAS was negatively related to delayed memory and not immediate recall or recognition of the same test. It is possible that holding NAS interfered with the process of free retrieval of learned material. Maybe impairments in the delayed recall were due to the frame of the test itself: participants are not notified in advance of the delayed recall that will take place 25 minutes later, and it is possible that being asked to reproduce the material learned previously challenged the participants in their NAS and increased situational anxiety. In addition, due to the correlational nature of this study, future projects could consider adding a cognitive baseline measure to exclude a potential relationship between NAS endorsement and undetected cognitive decline.

In this study, participants were offered a testing environment promoting older adults' cognitive performance and following guidelines for optimal cognitive testing in older adults. In our methodology, we included different levels of NAS within the same protocol, including explicit, implicit, self-perception, and self-relevance measures. Having these different levels of NAS was an important addition to the literature, as it allowed us to investigate how this group of older adults' performance has been impacted. Indeed, these findings demonstrate that explicit NAS can have a detrimental role on specific cognitive tests and suggest that older adults undergoing a neuropsychological assessment come in with a set of beliefs regarding older adults, in general, that could impair their performance. Importantly, these beliefs appear to interact with cognitive performance, independently of how old they are, how they perceive their aging, and beyond self-relevance, measured here by value and perceived competency. This is coherent with the literature, which has demonstrated that older adults do not have to endorse the stereotype to see their performance impaired necessarily, but that they must recognize that they belong to the stereotyped group and be mindful of the stigma attached to the social group (Spencer et al., 2016).

Conclusion

Patients undergo neuropsychological evaluations to understand better how their brain's health interacts with their thinking skills, emotional regulation, and behaviour. It is a multi-component evaluation in which, beyond the strict cognitive test scores, neuropsychologists need to consider variables that have been shown to interfere with performance on cognitive tasks, such as undetected temporary state of depression and anxiety, lack of motivation, and acute stress during testing that could lead to false-positive deficits, especially in the presence of mild cognitive complaints (Sachdev et al. (2013). Contextualizing test scores brings more clarity to their interpretation, allowing for the proper care and preventing unnecessary stress for the patient, reducing financial costs for the system, and mitigating risks of side effects from inappropriate therapies (Le Couteur et al., 2013). Our results support findings from previous work that social components such as stereotypes should be considered in interpreting older adults' cognitive scores. We also suggest that we consider older examinees in a systemic way when tested, as they may present with a positive self-view of aging, great collaboration, and motivation, but that more negative perceptions of older adults, in general, could interfere negatively with their cognitive performance.

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Exercising your Perception of Aging: Effects of Physical and Cognitive Training on Older Adults' Perception of their Own Aging

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Abstract

Objective: Satisfaction with one's aging has been suggested as a central aspect of subjective well-being in older age for decades but remains understudied despite evidence of internalized ageism among older adults. The first objective of this study was to investigate the impact of three interventions (two types of physical training or cognitive training) on negative aging stereotypes (NAS) endorsement and self-perception of aging (SPA). The second objective was to study whether there is a link between changes in cognition or fitness and SPA and NAS. The central hypothesis is that SPA will improve, and NAS endorsement will decrease in all three groups. SPA and NAS improvement should be linked to better cognition and fitness.

Methods: Sixty-one adults (M_{age}=70.42, *SD*=5.03; $M_{education}$=17.02, *SD*=4.0) were randomly assigned to aerobic, gross motor abilities, or cognitive training for three months. NAS (Fraboni scale of ageism, Implicit Association Test-Age), SPA (Attitudes towards own aging), fitness (Vo2Max; Energy cost walking), and cognitive tests (MoCA, BVMT-R) were administered pre-and post-intervention.

Findings: SPA significantly improved from baseline to post-intervention phase, independently of training type. SPA improved independently from changes in cognition and fitness. NAS remained stable from pre- to post-test in all groups.

Conclusion: Despite unchanged NAS endorsement, SPA improved through various types of training. Offering different types of exercise could reach a broader range of older adults with various interests and initial abilities.

Keywords: Self-perception of aging, negative aging stereotypes, physical training, cognitive training, older adults, cognition.

Public Significance Statement

From childhood, people have learned that with aging comes decrements and losses. A field in research has worked for decades to change these beliefs that are central to ageism and power imbalance in society. Interventions need to be developed to change the perception of aging so that, as a society, we benefit from the contribution of all individuals. Physical and cognitive interventions may be fun, accessible, and low-cost ways to challenge core ageist stereotypes vehiculating that age is inevitably associated with cognitive and physical decrements.

Exercising your Perception of Aging: Effects of Physical and Cognitive Training on Older Adults' Perception of their Own Aging

Ageism is prevalent in many functional domains, including work, relationships, and health, in which age discrimination and prejudice can have significant consequences. Older adults are less likely to be promoted in the workplace (Wood et al., 2008), physicians are more reluctant when they consider treatment options for their older patients (Robb et al., 2002), and older adults are more likely to be treated in ways that promote dependence (Baltes & Wahl, 1992) and be talked down to using patronizing speech (Hummert & Ryan, 1996). While older age may come with physical or cognitive difficulties, it is not inevitably a time of illness, frailty, and poor cognition. Aging is a variable process among individuals, which follows many different courses. Unfortunately, within-group variability is not socially recognized, and adults in later life are often targeted by negative aging stereotypes (NAS). They are seen as this homogeneous group characterized by a declining life course. This negative societal perception of aging, found in most cultures worldwide, is mainly driven by age stereotypes (Kotter-Grühn, 2015). Stereotypes refer to an individual's set of learned beliefs about the characteristics or attributes of a group (Judd & Park, 1993). Stereotypical construction results from the neglect of differences between individuals and over-generalizing group characteristics, leading to discrimination and ageism (Ayalon & Tesch-Römer, 2018). NAS is believed to contribute to negative self-perception of aging (SPA) in older adults (Levy et al., 2002), which corresponds to the cognitive evaluation of oneself relative to aging. Beyond biological mechanisms, psychological processes more amenable to interventions, such as NAS and SPA, have been suggested to play a significant role in the decrements in later life.

According to the Stereotype Embodiment Theory, lifetime exposure to NAS leads to the internalization of ageism, damaging self-perception of aging (SPA) (Levy et al., 2002). SPA refers to individuals' experiences and beliefs about their age process. A damaging aspect of stereotypes is when the targeted individuals begin to assimilate and include them as an accurate representation of themselves (Levy, 1996). These implicit stereotypes, embedded in each person's perspective of the world, are widespread and proven stronger than actual experiences (Levy, 2003). Moreover, when one cannot directly experience older age, stereotypes forged in youth create expectations about the future, which may develop into a self-fulfilling prophecy (Bennett & Gaines, 2010; Levy & Leifheit-Limson, 2009). When a person starts to identify as an older adult, their experiences are tainted by these stereotypes. They can act as a motivational incentive for behaviour (Hoppmann et al., 2007) or as a reference standard to evaluate actual experiences (Freund, 2007).

Longitudinal studies have shown that NAS and negative SPA among older adults were related to poor health, low well-being, and shorter survival times (Levy et al., 2012; Wurm & Benyamini, 2014; Wurm et al., 2007). Moreover, satisfaction levels with one's aging tend to decrease throughout life, coinciding with less attention to the individual's health care (Wurm et al., 2010). Having older adults consistently engage in behaviours promoting health, such as physical activity, is one of the most crucial contemporary challenges (Forberger et al., 2017). Many older adults feel reluctant to exercise and are one of the population's least active segments, failing to reach adequate physical activity levels worldwide (Hallal et al., 2012). This is unfortunate, as being physically active is linked to lower negative affect and stress, decreased pain levels, and physical symptoms. Altogether, these benefits have been linked to a better SPA.

However, NAS has been identified as a significant obstacle to older adults' commitment to physical activity (Chalabaev & Sarrazin, 2020).

Interventions Promoting Better Views of Aging

Exercise, implicit priming and psychological interventions combined. In a systematic review, Knight et al. (2021) investigated the effects of age stereotype-based interventions on older adults' health. Five of the eight studies reported improvements in physical function or activity. Methodologies included implicit priming or psychological intervention embedded into an exercise session (information targeting SPA). For example, Brothers and Diehl (2017) found they could increase physical activity by challenging negative views of aging. By increasing awareness of age-related changes, NAS, and age-related expectations, participants doubled their weekly minutes of physical activity from baseline. Beyer et al. (2019) provided information targeting SPA embedded into an exercise session. Compared to an exercise-only control group, participants who received the supplementary psychological intervention reported lower depression levels and a more positive SPA. In a different study, participants received a personalized three-month walking program associated with counter-stereotypical information about the benefits of physical activity for older adults (Emile et al., 2014). These participants significantly improved their perception of the benefits of exercise. The perceived activity risks in older women have also been reduced compared to a passive control group.

Physical interventions only. Klusmann et al. (2012) were the only research group in this review by Knight et al., (2021) to explore the implicit impact of exercise as the sole intervention strategy. The authors found an improvement in age satisfaction for older female adults who followed a six-month exercise intervention three times a week compared to a computer-course intervention program group and a passive non-intervention control group.

Most of the studies included in the review by Knight et al. (2021) appear to have focused on the stereotype embodiment theory by Levy (2009) and aimed at changing long-lasting beliefs about aging through psychoeducation combined with exercise. However, all individuals may not have access to psychoeducation services in the community, which puts them back in a position of dependence on others to optimize their health. From the perspective of helping individuals to challenge their assumptions about aging and improving their SPA, there is a need to develop types of intervention that can be accessed with more autonomy. In line with Klusmann et al. (2012), older adults may improve their SPA through exercise only. Physical activities are an implementable and low-cost intervention that continues to show benefits for older adults' global health (Harridge & Lazarus, 2017), cognition (Erickson et al., 2019), and well-being (Aguiñaga et al., 2020). However, little is known about the impact of exercising on SPA.

Furthermore, given the heterogeneity of older people's abilities and interests, developing more personalized programs and measuring the effectiveness of different exercise types could reach more individuals. The value of various forms of physical activity in health promotion has been universally acknowledged for decades (Edwards et al., 2005). Designs in the field of exercise science and psychology often involve studying different types of training exercises such as balance, aerobics, strength, coordination, and group sports (Levin et al., 2017), not to mention the inclusion of variables such as duration or levels of intensity. Research on the relative impact of exercising on SPA is at its premises; however, given the accumulated knowledge in the field of exercising and psychology, it could be relevant to refine the designs and be more specific in the targeted physical abilities trained that are thought to improve SPA.

Cognitive training. Cognitive training is a controversial intervention to improve cognitive functioning in non-trained domains (Gobet & Sala, 2022). Nevertheless, few studies have looked at whether cognitive training could have an impact on self-perception. Goghari and Lawlor-Savage (2018) found that individualized cognitive training in working memory, logic, and planning may enhance the subjective perception of cognitive functioning and self-efficacy in daily life in healthy older adults. These findings were coherent with a previous study that found that reasoning training resulted in a less self-reported functional decline in older adults (Willis et al., 2006). However, Bures et al. (2016) found that cognitive training did not improve older adults' well-being compared to leisure time activities. To our knowledge, no study has looked at how cognitive training could directly improve SPA and decrease NAS.

Satisfaction with individual aging has been a central aspect of subjective well-being in older age for decades (Lawton, 1975; Neugarten et al., 1961). However, despite evidence of internalized ageism among older adults, it remains a domain that received little attention in the scientific community (Kleinspehn-Ammerlahn et al., 2008). Furthermore, many studies aimed at modifying subjective age, conceptualizing that feeling younger improves SPA, but only a few aimed at making older adults feel more positive about their aging process. As Kotter-Grühn (2015) pointed out, interventions aiming at changing SPA should be sensitive not to perpetuate NAS, or they may end up in a paradox: aiming at gaining a more positive SPA by subjectively feeling younger. Being old, feeling old, or looking old, is not what is wrong, but disengaging prematurely or avoiding activities, with the premise that age defines what one can do, is.

Furthermore, studies that aimed at identifying situational variables and circumstances in which older adults may feel more positive about their age are often correlational and do not allow for causal or directional conclusions (Kotter-Grühn, 2015). Globally, in this field of research, targeting interventions to improve SPA requires more attention and specific methodologies to draw firm conclusions. Investigating different types of training may be relevant when it comes to implementation in the community and considering older adults' interests and individual characteristics.

The present study investigates the impact of lifestyle interventions designed to improve cognition and fitness, which could also improve SPA and decrease NAS endorsement.

The objectives are 1) To study the impact of two types of physical training (fitness and gross motor abilities) and cognitive training on NAS endorsement and SPA and 2) To study if the improvement in SPA covaries with improvements in cognition and fitness. Hypotheses are that 1) SPA will improve and NAS endorsement will decrease regardless of the intervention, and 2) SPA should improve as a function of better cognition or fitness.

Method

Participants

Sixty-one right-handed adults participated in this study. Inclusion criteria were adults 60 years and older, male and female, fluent in French or English, sedentary, in good health and mobility, and without any contraindications to performing physical activities. Exclusion criteria were: smoking within the past five years, more than two alcohol units per day, a history of alcohol or drug abuse, current somatic or psychiatric disorder, surgery or other medical intervention involving a general anesthetic in the past six months, unstable medical problems (cardiorespiratory illness, cardiac troubles, palpitations) in the year preceding the protocol, a body mass index <18.5 or >29.9 kg/m2, significant and uncorrected sensory impairments, severe tremors or involuntary movements, a history of a severe injury to any upper limb currently affecting mobility, severe or recurrent epilepsy, a diagnostic or treatment for severe depression in the past five years, undergoing any hormone therapy treatment, thyroid or pituitary disease, neurological disease, early signs of dementia (Mini-Mental State Examination, MMSE <26), depressive symptoms (Geriatric Depression Scale, GDS ≥11), and participation in an intervention study or program over the last year.

This study was a subproject of a major randomized controlled trial primarily designed to determine the effects of 12-week exercise interventions on health and mobility in aging (Pothier et al., 2021). All participants provided written informed consent for this project, although they were unaware of the objective of this sub-project.

Measures

Screening protocol. All participants completed the following tests for the screening procedure during the pre-intervention session in this sequence:

Mini-mental examination test (MMSE; Folstein, Folstein & McHugh, 1975). This test is commonly used for cognitive screening in research and clinical settings. It measures cognitive function, including orientation, word recall, language abilities, attention, and visuospatial memory. A score of 27 and above is considered normal.

Selected subtests of the Wechsler adult intelligence scale fourth Edition (WAIS-IV) (Wechsler et al., 2008). This test is the most frequently used measure of intelligence for children, adolescents, and adults (Kaufman & Lichtenberger, 2006). The WAIS-IV was normed on 2,200 people aged 16 to 90, from which 600 were adults over 65 (M= 75.68, SD= 7.68). For people 65 years of age and older, reliability coefficients for the WAIS-IV subtests range from r = .78 to r = .98 (Wechsler, 2008).

Digit Span forward/backward. This subtest is part of the Working Memory Index. It requires attentional and short-term memory abilities and the ability to manipulate information mentally. Participants are asked to repeat a series of numbers in the same order as presented and in reverse order.

Similarities. This subtest is part of the Verbal Comprehension Index. It measures abstract verbal reasoning and semantic knowledge by describing how two objects or concepts are similar.

Coding. This subtest measures information processing speed and efficiency and is part of the Processing Speed Index. It is a complex task requiring multiple cognitive abilities, including attention, cognitive flexibility, visual scanning, and motor coordination (Joy et al., 2003; Sattler & Ryan, 2009). The participant is initially shown a key containing the numbers 1 to 9. Under each number, there is a corresponding geometric symbol. The participant is then shown a series of boxes containing numbers in the top boxes and blank boxes below. After a short practice trial, they are asked to copy the corresponding symbols under each number. Participants are told to go as fast as they can without making mistakes. The raw score is the number of correct items within the prescribed time limit (120 seconds).

The Geriatric depression scale (GDS) (Yesavage et al., 1983). The GDS Long Form (30 items) has been tested and used extensively with the older population. Participants respond by answering yes or no about how they felt over the past week. Scores of 0-9 are considered normal, depending on age, education, and complaints; 10-19 corresponds to mild depressive symptoms and 20-30 to severe depressive symptoms. The GDS was found to have a 92% sensitivity and an 89% specificity when evaluated against diagnostic criteria in both clinical and research settings. A validation study (Sheikh & Yesavage, 1986) compared the Long and Short Forms of the GDS for the self-rating of symptoms of depression. It showed that both successfully differentiated depressed from non-depressed adults with a high correlation ($r = .84$, $p < .001$).

Primary outcomes. Participants completed measures of NAS, SPA, and perceived competency to perform cognitive and physical tests. Questionnaires were completed at home after the testing session.

The fraboni scale of ageism (FSA); Fraboni et al., 1990). This measure was used to assess participants' explicit NAS endorsement of older adults in general. The FSA construct is derived from Butler's (1978) definition of ageism. It is a validated measure of external ageism designed to assess both cognitive and affective components of ageism. The participants answer 29 questions on a 4-point Likert Scale, going from "strongly disagree" to "strongly agree," with higher scores meaning higher ageism. It produces a global score for ageism and three individual scores for levels of prejudice: Discrimination (biased opinions regarding political rights, segregation, and activities of older adults, e.g., " It is best that old people live where they won't bother anyone"; Most old people are interesting, individualistic people"), Avoidance (withdrawal from social contact with older persons, e.g., "Feeling depressed around old people is probably a common thing"; Old people can be very creative"), and Antilocution (antagonism and antipathy fuelled by misconceptions, misinformation, or myths about older persons, e.g., "Many old people complain more than other people do," "Most old people should not be allowed to renew their driver's licenses"). Cronbach's coefficient alpha reliabilities of the Antilocution, Avoidance and Discrimination subscales were reported as .76, .77, and .65, respectively. A more recent study by Credé et al. (2003) revealed an alpha reliability estimates of these subscales were .75, .61, and .77, respectively. The global internal-consistency reliability coefficient is .86 and showed a lack of influence from social desirability (Fraboni et al., 1990).

Implicit association test-ageism (IAT; Greenwald et al., 1998). This measure assessed participants' implicit NAS endorsement of older adults in general. Implicit social cognition, such as attitudes and stereotypes, often operates automatically and without awareness to affect judgments and behaviours (Greenwald & Banaji, 1995). The IAT has been largely used to measure automatic attitudes, stereotypes, and identity in various domains, including age (Greenwald & Nosek, 2001). The IAT is weakly associated with self-report measures of the same construct, which suggests that the IAT assesses processes that are often distinct from the corresponding constructs measured by self-report (Dasgupta & Greenwald, 2001; Greenwald & Farnham, 2000; Greenwald & Nosek,2001; Lee Hummert et al., 2002). The fundamental assumption of the IAT-Age is that judgments congruent with participants' implicit associations of the older adult's category with an evaluative category, such as old and unpleasant, will be easier and made more quickly than those that are incongruent, such as young and unpleasant. A computerized version was used in which the participant was presented with photographs of young and old adults (at the center of the screen) one at a time and paired each picture as quickly as possible with an evaluative word (pleasant-unpleasant). The speed at which this pairing was completed in the congruent association compared to the incongruent one was interpreted as a measure of the strength of an implicit association (attitude). A meta-analysis by Greenwald et al. (2009) found an average $r = .274$ for predicting behavioural, judgment, and physiological measures by IAT measures. This meta-analysis also revealed that age, ethnicity, and weight were group categories in which the predictive validity of IAT significantly exceeded that of self-report measures.

Attitudes toward own aging (ATOA, subscale of the Philadelphia geriatric center morale scale, Lawton, 1975). This questionnaire was used to measure what participants think about themselves as they age. The Philadelphia Geriatric Center Morale Scale is designed to assess the psychological state of older people using a multidimensional approach (Lawton, 1975). The subscale Attitudes Toward Own Aging includes items related to the older person's experiences of their aging process and their perception of the changes in their life. Respondents are asked to indicate yes or no to 6 statements (e.g., "As you get older, you are less useful," "I am as happy now as when I was younger"). Higher scores mean a better perception of own aging. Internal consistency was found to have an alpha of 0.81 for this subscale.

Measures of self-perception in cognitive or physical performance. This questionnaire was initially designated to measure adolescents' achievement task values and expectancy-related beliefs for mathematic performance (Eccles & Wigfield, 1995). It was adapted here for older adults to assess their competency to perform well at cognitive and physical tests and the degree to which they valued doing well. The questionnaire included 10 questions ranging on a seven-point Likert scale. The total score is the product of the 10 questions mean and relates to the degree of motivation and confidence to perform well at cognitive or physical testing.

Of interest in our study were the subscales of Value and Competence that are extracted by averaging selected items together. Value is the average of five questions: "Is the amount of effort it will take to do well on the most difficult memory and attentional tasks worthwhile to you?" (1 being Not very worthwhile and 7 Very worthwhile), "How is it important to you to get good results on memory and attentional tasks?" (1 being Not at all important and 7 Very Important), "I feel that it is important being good at completing memory and attentional tasks" (1 being Not at all important and 7 Very Important), "In general I find participating in memory and attentional testing… (1 being Very boring and 7 Very interesting) and "How much do you like doing memory and attentional testing?" (1 being Not very much and 7 Very much). Competence is obtained by averaging five questions: ("If you were to order all the participants in this research project from the worst to the best in memory and attentional tasks, where would you put yourself?" (1 being The worst and 7 being The best), "Compared to other participants, how well do you expect to do on memory and attentional tasks? (1 being Much worse than the other participants and 7 being Much better than the other participants), "How good are you at memory and attentional tasks? (1 being Not at all good and 7 Very good)," How have you been doing so far in your life with memory and attentional tasks? (1 being Very poorly and 7 Very well), "How well will you do on the memory and attentional tasks in this research project?" (1 being Very poorly and 7 Very well). The same questions were asked related to physical tasks.

Of note, in questions involving a comparison component, participants were aware that "other participants" were aged 60 and over.

Secondary outcomes. All participants completed these cognitive and fitness tests.

Montreal cognitive assessment (MoCA)(Nasreddine et al., 2005). This test measures cognitive function, including orientation, memory, executive function/visuospatial ability, language abilities and naming, abstraction and attention. It also includes a clock-drawing test. This test was designed to assist health professionals in screening for mild cognitive impairment and Alzheimer's disease. The cut-off considered normal is 26, with an adjustment for individuals with 12 years of education and lower (+ 1 point to the final score).

The brief visuospatial memory test-revised (BVMT-R; Benedict et al., 1996). This test measures visual learning and memory using a multiple-trial learning paradigm. Participants are presented with six geometric visual designs in a 2 X 3 matrix, for which they are required to retain their placement in the space and their details. The matrix is shown for 10 seconds for three learning trials, and participants reproduce the matrix following each presentation. The immediate reproduction of these forms assesses for immediate recall, and their reproduction measures delayed recall after a 25-minute delay. This test ends with the adequate recognition of the six forms among six distractors. Gender was not found to influence most aspects of recall and recognition performance (Benedict, 1997). However, age was found to moderately correlate (r = -.44 to -.50) with BVMT-R scores (Benedict et al., 1996) and accounted for about 11% of their variance (Benedict, 1997). Correlations between age and recognition performance were not significant. The impact of education as a predictor has led to mixed results. Benedict et al. (1996) found that correlations were weak (r =.20), and consequently, the standard T-scores generated for the test only corrected for age. However, education was found to be a significant predictor of BVMT-R scores in subsequent studies (Norman et al., 2011; Wit et al., 2017). The reliability coefficient for this test varies from marginal to high, ranging from .60 for Trial one to .84 for Trial three. The reliability coefficient for the total recall score is .80 (Benedict 1997).

Cardiorespiratory fitness ($V0_2Peak$). A certified exercise physiologist administered this test. Peak oxygen uptake was used to assess participants' cardiorespiratory fitness (see Berryman et al., 2013, for the detailed protocol). The maximal aerobic power (MAP) was measured, corresponding to the highest mechanical power output during the cardiorespiratory fitness test. All participants completed a maximal graded exercise test on a cycle ergometer (Lode, CORIVAL). They were equipped with an electrocardiogram to monitor heart rate and wore a mask that covered their mouth and nose to measure gas exchanges during the test (analyzed using the Medgraphics CardiO2 Metabolic Cart and Breezesuite software; Medical Graphics Corporation and Medisoft SA, United States of America). After the calibration procedure, participants started at a pre-defined workload (35 W for women and 50 W for men), with a 15 W increase every minute regardless of sex. Participants needed to maintain a pedalling rate of 60 to 80 rpm. Testing was completed when participants could no longer hold the cadence or according to criteria described by the American College of Sports Medicine (ACSM, 2001). VO_2Peak was defined as the highest volume of oxygen consumed over a 30 s interval in $ml.kg^{-1} .min^{-1}$. Cardiorespiratory fitness was previously associated with good test-retest reliability in older adults with r = 0.67–0.90 (Huggett et al., 2005).

Energy cost of walking (ECW). Using the same metabolic cart as during the VO_2Peak test, walked on a treadmill for 6 minutes at a constant speed of 4 km. h^{-1}. The ECW was calculated as described in Pothier et al. (2021). The oxygen uptake of walking (representing the mean VO_2 from the last 2 minutes of the walking task, in ml. kg $^{-1}$.min $^{-1}$) was divided by the walking speed (m.min $^{-1}$) to obtain the oxygen cost of walking in ml. kg $^{-1}$.m $^{-1}$. Values in ml. kg $^{-1}$.m $^{-1}$ were then converted into L. kg $^{-1}$.m $^{-1}$. The energy equivalent of oxygen (J.L $^{-1}$) was used to convert the previously calculated oxygen cost of walking (L.kg $^{-1}$.m $^{-1}$) into J.kg $^{-1}$.m $^{-1}$ (Peronnet & Massicotte, 1991) to obtain a suitable ECW. This was done using the respiratory exchange ratio (RER) corresponding to the last 2 minutes of walking. These procedures are coherent with the literature for moderate-intensity exercise, with the advantage of considering substrates metabolized during exercise (Fletcher et al., 1999). Measurements were considered valid if the oxygen steady-state and RER values were less than one during the last two min of walking. Good test-retest reliability for the ECW was observed in a sample of 43 participants (including 20 older adults): Intraclass Correlation Coefficient = 0.86 and Coefficient of Variation = 3.4% (Gaesser et al., 2018).

Procedure

Before the training, all participants had a medical visit performed by a geriatrician to collect clinical data and ensure they could participate safely in a physical training program. Participants completed pre-intervention cognitive measures and questionnaires measuring NAS, SPA, and sense of competency in performing cognitive and physical tasks. They also underwent the IAT-ageism computerized task to measure implicit NAS. All NAS and SPA measures were administered after cognitive tests to prevent the potential activation of stereotypes that could interfere with performance. Participants were randomized into one of three training interventions: Gross Motor Abilities (GMA), Aerobic (AE), and Cognitive training (COG). A research assistant trained in neuropsychology supervised the cognitive training, while a licensed kinesiologist supervised the aerobic and gross motor abilities training. During the research study, participants were given clear instructions about maintaining the same life habits. After completing the intervention program, participants were assessed for cognition, fitness, and NAS endorsement. In total, participants underwent a 12-week program, including 36 sessions lasting 60 minutes three times weekly.

Interventions

Gross motor abilities intervention. This training was based on a protocol from Pothier et al. (2021) study. The training targeted balance and agility abilities and aimed at improving coordination. Each of the three sessions included a ten-minute low-intensity walking exercise on a treadmill with increasing difficulty up to a speed of 4 km/h with a 1% incline. After the warm-up, each session of the week had its specific focus for 30 minutes: one session prioritized locomotion and lower body coordination, a second session targeted balance, and the last session prioritized hand-eye coordination, such as throwing or aiming. The difficulty level increased as the intervention progressed, combining multiple skills simultaneously (coordination, balance, agility). All sessions concluded with 5 minutes of stretching to increase body flexibility and to let participants cool down.

Aerobic intervention. This training was designed by Pothier et al. (2021) to increase cardiorespiratory fitness by alternating between high-intensity intervals and moderate-intensity continuous sessions. All sessions followed the same warm-up protocol so that participants completed 10 minutes at 50% of their maximal aerobic power (MAP). In high-intensity interval sessions, participants performed two sets of 5 minutes of high-intensity interval (including a two-minute rest in-between sets) alternating between 15 s bouts of cycling (LifeFitness, Kinequip, St-Hubert, Quebec) at intensities corresponding to 100% of participants' MAP, with 15 s recovery at 60%. Moderate-intensity sessions included 20 minutes of continuous cycling at 65 % MAP. Every session concluded with 10 minutes of cool-down at 50% of their MAP. As the intervention progressed, the exercise intensity was increased according to each participant's MAP by 5% each month. Therefore, all participants increased to 75% MAP in the moderate-intensity section by the end of the training protocol and to 110% MAP high-intensity section.

Cognitive intervention. This training took place in a quiet room, with participants seated in front of an individual tablet equipped with a web-based computerized neuropsychological battery. The training included a Dual-task, Stroop, and N-Back, three tasks targeting executive functions. Instructions, difficulty manipulation, and individualized feedback were provided to optimize performance, with difficulty levels increasing throughout the 12-week intervention. Each training session was composed of 20 minutes of each of the following three tasks for which participants were instructed to answer as fast as they could without making mistakes:

The Dual-Task paradigm (Lussier et al., 2020). Involves performing two different tasks alone or concomitantly. This task requires the discrimination of three stimuli by pressing the corresponding button with the left thumb or/and discriminating three others with the right thumb. Stimuli were presented in visual or auditive modalities and included fruits vs. means of transportation, letters vs. numbers, or sound vs. beeps. Following two training sessions, participants were required to prioritize one hand over the other during the dual-task condition to increase the difficulty level and maximize training effects.

The Stroop task. Involves familiarization, reading, counting, inhibiting, and switching, five conditions which were also used at pre- and post-intervention sessions. However, different stimuli (letters and symbols vs. numbers) were presented to prevent a training effect on post-test intervention testing.

The n-back task. Involves the sequenced presentation of either a group of nine consonants or six symbols. Participants were asked to indicate if the current stimuli matched the one from one to three steps before the sequence. Stimuli were presented in visual and auditive modalities concomitantly, and two buttons (a top button for "is the same" and a bottom button for "is different") were displayed on the right side of the tablet so that participants could answer using only their right thumb. During the first month of training, only one and two steps back were administered, the three steps back condition was incorporated at the beginning of the second month, and for the third month, only two and three steps back were administered.

Randomization Process

Participants' confidential information linking their identity to data was kept in a password-protected computerized file, which only the study coordinator had access to. To reach equivalence for age, education level, and gender at baseline, a random sequence was generated using SPSS. Then it alternated each participant until the training groups reached equivalence within a 95% confidence interval. Participants were aware of the three training groups and knew they would not be able to choose their assignment. After completing pre-intervention tests, they were informed of their placement within their group. Evaluators at pre- and post-intervention testing were blind to the participants' group assignment, and trainers were not involved in the pre-and post-intervention testing sessions.

The Sample of Participants Analyzed

Sixty-one participants were included in the analysis among the 73 participants eligible at baseline. For four participants, drop-outs occurred due to changes in their health or physical condition; two dropped out for personal reasons (e.g., travel time, high frequency of training), one was excluded due to too many absences, two dropped out during pre-intervention testing or after the first training, and three for unknown reasons (see figure 2). To be included in the final analysis, participants needed to have attended at least 75% of the training sessions. All analyses were completed with the entire data set, including 61 participants.

Transparency and Openness

We have disclosed the process by which we determined our sample and described all data exclusions, manipulations, and measures in this study. To the best of our knowledge, our analysis only included participants that met inclusion criteria and were free from any exclusion criteria. Deidentified data and analysis can be made available upon request. Stimulus materials and protocols are copyright protected and cannot be provided.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS 20 for Windows. Kurtosis and skewness were assessed for all variables and normality was investigated by the evaluation of the Q-Q plots and histograms Extreme scores were screened using the outliers labeling rule with a factor of 2.2 (Hoaglin & Iglewicz, 1987). Only one observation was randomly missing at baseline for ECW, which was replaced by the mean of the entire sample (Lachaud & Renaud, 2010).

Split Plot repeated measures ANOVAs were used to explore the effect of the three training groups on NAS and SPA measures (ATOA, FSA, and IAT), with time (pre-post) as the within-subject factor and interventions as the between-subject factor. Eta squared are reported as effect sizes. GDS was close to being statistically significant between groups at baseline and is conceptually associated with SPA, with a correlation of r (58) = -.413, p=.001 between the two measures. GDS was included as a covariate in the model in the form of a standardized score to explore if a change in SPA covaried with a change in GDS. Correlations were used to investigate potential associations between NAS variables, cognitive (BVMT-R, MoCA), fitness measures (VO_2Peak and ECW), and training attendance (number of sessions attended). Linear regressions were used to investigate whether a change in fitness or cognition would predict a change in NAS or SPA. Change scores were calculated by transforming the data into standardized z scores.

Results

Baseline Data

All three groups were equivalent in demographic characteristics, screening measures, and baseline NAS and SPA endorsement (see table 1). No group differences were observed for baseline cognitive abilities, except visuospatial memory, with participants in the Aerobic group performing 2 points lower than the Gross Motor Abilities group.

Table 1

Baseline descriptive values (means or percentage, standard deviations)

Characteristic	All sample *N*=61	AE *n*=20	GMA *n*=22	COG *n*=19	*F* or χ^2	p
Age	70.42 (5.03)	69.4 (5.53)	71.08 (3.79)	70.71 (6.02)	.684	.51
Education level (years)	17.02 (4.00)	17.56 (4.37)	17.05 (4.27)	16.53 (3.64)	.32	.73
Male (%)	34.43	25.00	27.27	52.63	χ^2= 5.92	.02
Attendance	33,15 (2.02)	33.50 (1.54)	33.00 (2.41)	33.21 (2.15)	.26	.77
MMSE	28.46 (1.21)	28.83 (.92)	28.30 (1.30)	28.21 (1.18)	2.08	.13
MoCA ST	26.38 (2.53)	26.72 (2.47)	26.15 (2.68)	26.16 (2.67)	.40	.67
Visuospatial Memory	6.69 (3.07)	5.94 (2.92)	7.90 (3.06)	6.05 (3.17)	3.15	.05
Processing speed	58 (11.81)	59.61 (11.60)	58.40 (11.75)	54.89 (11.86)	.96	.39
Working memory	17.43 (3.96)	17.72 (3.83)	17.20 (3.69)	17.37 (4.30)	.00	.10
Abstract verbal Reasoning	24.72 (4.71)	25.50 (2.96)	25.50 (5.75)	23.32 (4.96)	1.28	.29
ATOA	4.54 (1.54)	4.72 (1.23)	4.40 (1.73)	4.74 (1.52)	.93	.40
FSA	54.62 (8.75)	55.50 (9.29)	54.10 (9.41)	55.32 (8.12)	.10	.91
IAT (*z*)	.7572 (.4549)	.7454 (.3894)	.7253 (.4760)	.8343 (.4943)	.45	.64
GDS	4.77	2.3	5.86	6.11	3.14	.051

(5.57)	(2.45)	(5.31)	(7.36)

Abbreviations: MMSE=Mini Mental State Examination; MoCA ST= Montreal Cognitive Assessment with the level of education; ATOA= Attitudes Towards Own Aging; FSA= The Fraboni Scale of Ageism; IAT= Implicit-Association Test reported in *z* score; GDS= Geriatric Depression Scale.

Intervention Effects on the NAS Outcomes

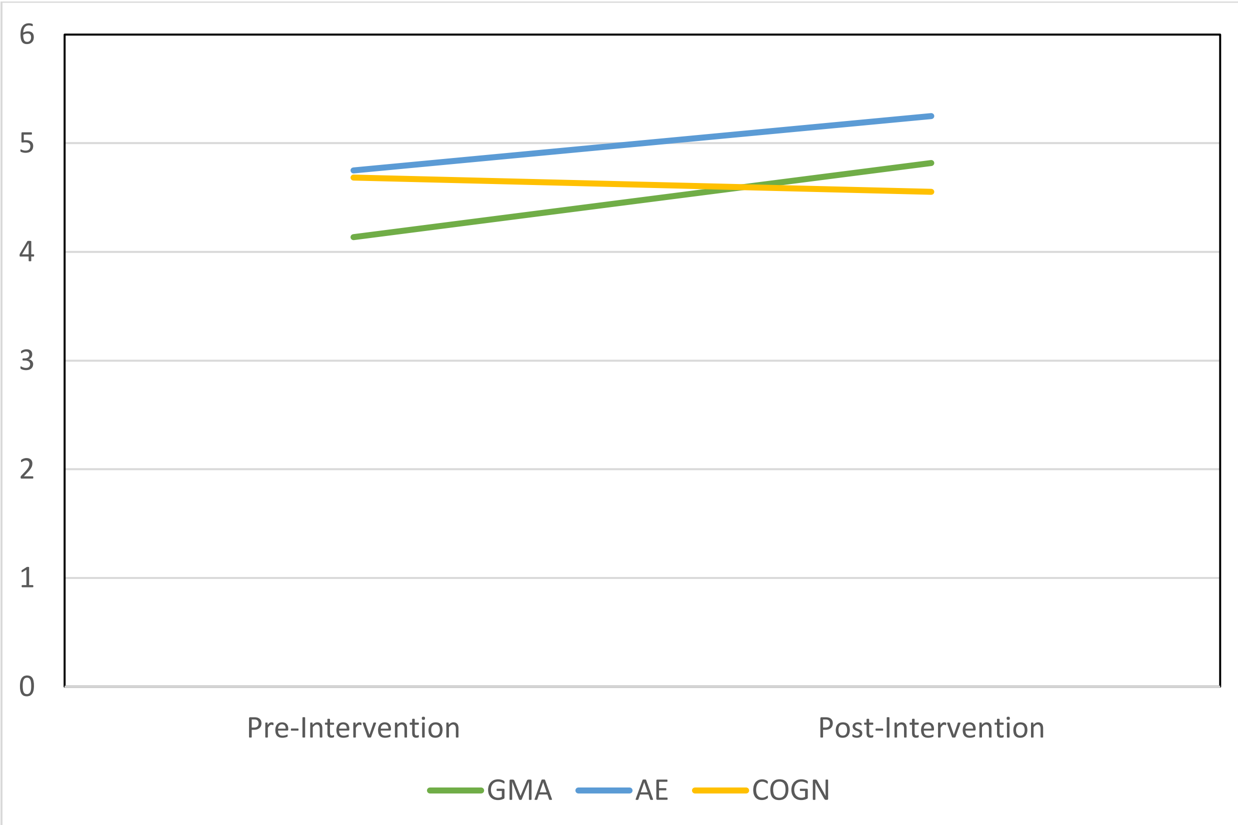
Repeated measures analysis of variance. SPA as measured by the ATOA statistically improved with time, $F_{(1,58)}$ =4,29, p=.043, η^2= .069, but did not show a group*time interaction, $F_{(1,58)}$ = 2.69, p= .077, η^2= .085. This could indicate that all three groups improved in SPA after training. However, a closer look at the means showed a tendency for the physical training groups to improve (GMA_{pre}=4.1, GMA_{post}=4.8; AE_{pre}=4.8, AE_{post}=5.3), whereas the cognitive group slightly declined (COG_{pre}=4.7, COG_{post}=4.6). Once GDS was added as a covariate in the model, SPA still significantly improved with time $F_{(1,58)}$ =5.69, p=.020, η^2= .091, and did not statistically covary with GDS change $F_{(1,58)}$ =3.07, p=.085, η^2= .051. Explicit NAS (FSA) did not improve statistically over time $F_{(1,58)}$ =, p= .69, η^2= .003, and was equivalent between groups $F_{(2,58)}$= 1.534, p=.22, η^2=.05. Similar results were obtained on the implicit measure of NAS (IAT), which did not show a time effect, $F_{(1,53)}$ =.740, p= .39, η^2= .014, or group difference $F_{(2,53)}$=.250, p=.78, η^2= .009.

Visuospatial memory delayed as measured by the BVMT-R statistically improved with time and by group, $F_{1,57}$ (3.166) *p*=.05 η^2 =.100, just as the MoCA $F_{1,56}$ (3.162) p=.05 η^2=.101. ECW improved with time and by group, $F_{1,57}$ (4.872) p=.01 η^2 =.146 as well as Vo2Peak, $F_{1,58}$ (5.378) p=.007 η^2=.156.

Correlations and regressions. Correlations were nonsignificant between SPA and demographic variables, including age (*r*=.081, p=.535), sex (*r*=.127, p=.329) and education (*r*=.64, p=.627). Subsequent analysis showed no significant interaction between baseline SPA and fitness measures (VO_2Peak *r*= -.059, p=.65; ECW *r*= -.16, p= 0.22) and between change (pre-post) in SPA and change in fitness (VO_2Peak *r*= -.010, p=.942; ECW *r*= -.191, p=.14). Correlations were also nonsignificant between SPA and cognitive measure at baseline (MoCA *r*= -.109, p=.41; BVMT-R Delayed *r*= -.150, p=.25) or between change (pre-post) in SPA and change in cognition (MoCA *r*= -.040, p=.76; BVMT-R Delayed *r*= -.203, p=.12). Correlations showed no significant interaction between FSA, fitness measures at baseline (VO_2Peak *r*= .132, p= .31; ECW *r*= -.012, p=.93) and cognitive measures at baseline (MoCA *r*= -.115, p=.38; BVMT-R *r*= -.178, p=.17). Correlations were also not significant between IAT and fitness at baseline (VO_2Peak *r*=.027, p=.85; ECW *r*= -.21, p=.88) or cognition at baseline (MoCA *r*= -.16 p=.25; BVMT-R *r*= -.087, p=.52). When investigating the motivation, only change in ATOA and change in motivation to perform well at physical tests interacted significantly (*r*= .32, p= .015). More specifically, a change in value to perform correlated with a change in ATOA (*r*=.381, p=.003), but no change in perception of competency (*r*=.085, p=.52).

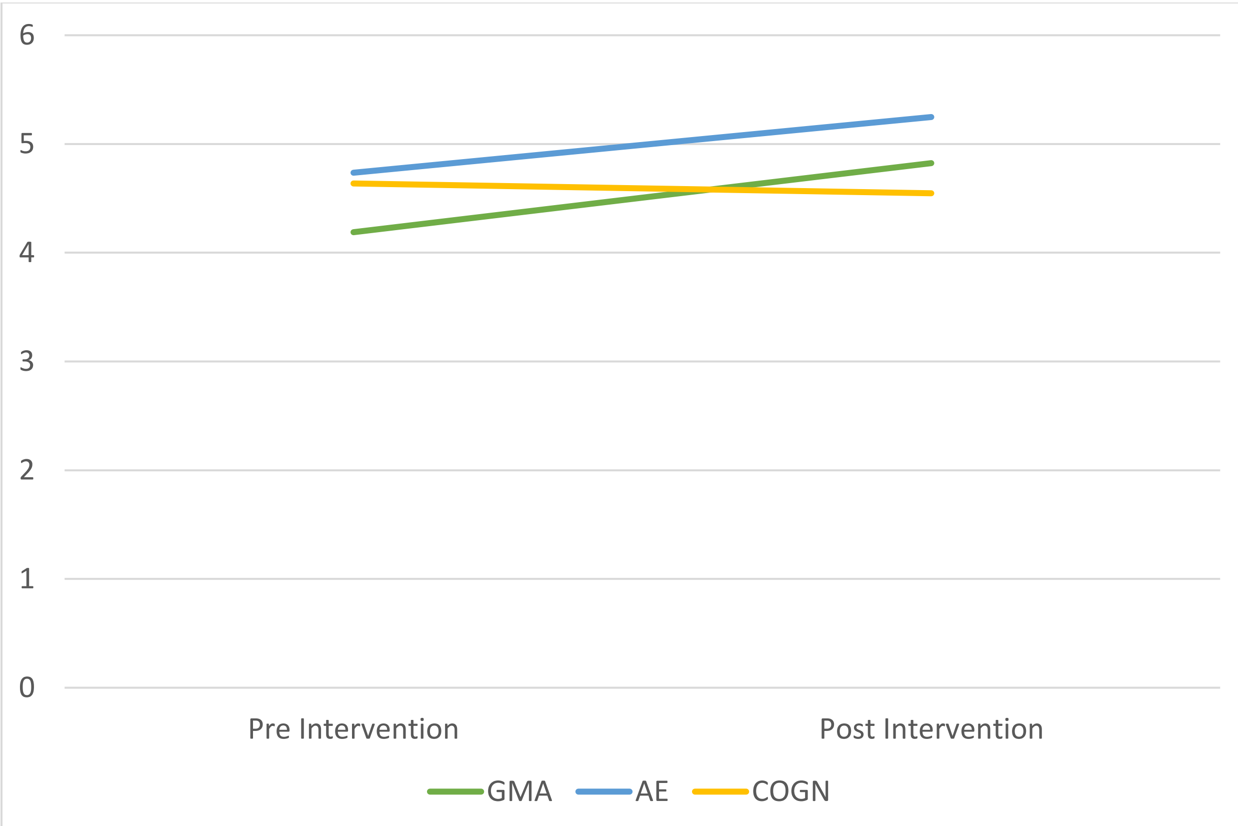
Simple linear regression showed that change in motivation to perform physical tests explained variance in ATOA change (β=.32, p=.015).

Figure 1. Results from the ANOVA, ATOA pre-post intervention



GMA=Gross Motor Ability training group; AE= Aerobic training group; COGN=Cognition training group

Figure 2. Results from the ANCOVA, ATOA pre-post intervention with GDS as a covariate



ATOA= Attitudes Towards Own Aging scale; GDS= Geriatric Depression Scale; GMA=Gross Motor Ability training group; AE= Aerobic training group; COGN=Cognition training group

Discussion

The first objective of the present study was to investigate the impact of two types of physical training (fitness and gross motor abilities) and cognitive training on NAS endorsement and SPA. The second objective was to study whether the improvements in SPA covaried with improvements in cognition and fitness outcomes. Hypotheses were that 1) SPA would improve and NAS endorsement would decrease among participants, and 2) SPA should improve as a function of better cognition or fitness.

Confirming the first hypothesis, SPA significantly improved from pre- to post-intervention in all three groups, with a medium magnitude of time effect. Our results align with the emerging literature supporting physical exercise as an efficient intervention to enhance views of aging. In Klusmann et al. (2012), participants who underwent six months of aerobic endurance, strength, flexibility, balance, and coordination training, reported a decrease in aging dissatisfaction and increased motivation to exercise. The literature has shown the effectiveness of adding a psychological intervention targeting SPA to improve older adults' self-views, yielding to larger treatment effect results (Beyer et al., 2019; Knight et al., 2021). Our results suggest that in the absence of such psychological resources in the community, older adults could fairly see their SPA improved just by exercising. Moreover, our study explored the relative impact of two different exercise types on SPA. Although this needs replication, our results suggest that cardiovascular-based and gross-motor-based programs could just be as efficient. Developing knowledge about different types of exercise could be relevant when considering older adults' interests and abilities.

Brothers and Diehl (2017) found the effectiveness of changing views of aging to promote increased physical activity. The authors based their intervention (Aging^{plus} program) on the literature supporting those negative views of aging appear modifiable (Kotter-Gruhn, 2015) and associated with physical health and behavioural performance. The literature indeed supports faster walking speed (Hausdorff et al., 1999), improved grip strength (Stephan et al., 2013), and increased exercise behaviour (Sarkisian et al., 2007; Wolff et al., 2014) in older adults holding more positive views of aging. Coherently, Emile et al. (2014) examined the effects of a walking program on stereotypes associated with exercise, quality of life, and health-related function of older sedentary women. They found that two weekly 45-minute supervised walking sessions for three months improved beliefs about the benefits of physical activity in older age, quality of life, and perceived physical value and competence. These findings could be coherent with our results, showing an association between increased intrinsic motivation to perform physical tasks and better SPA without having a link between improved fitness and better SPA. The psychological benefit of exercising may be enlightening to enhance views of aging. These results support an association between improved SPA and exercising behaviours, which suggests that exercise has the potential to overcome subjective ageist bias and promote health in older adults.

Without being statistically significant, we observed that SPA improved in physical exercise groups, while participants in the cognitive training group remained stable over time. This observation motivates the necessity of investigating further the effects of cognitive training on SPA compared to exercising. Cognitive training is increasingly popular as a non-pharmacological intervention for improving cognition in healthy aging (van Balkom et al., 2020), particularly for working memory and reasoning skills (Klimova, 2016). Meta-analyses have also supported the efficacy of this type of training in improving cognitive functions in neurodegenerative diseases (Chandler et al., 2016; Dardiotis et al., 2018; Leung et al., 2015). Interestingly, computer-based cognitive training has been shown to improve one's perception of daily cognitive functioning, suggesting it may enhance cognitive self-efficacy in healthy older adults (Goghari & Lawlor-Savage, 2018). However, since most studies focus on the preservation of cognitive function, psychological implications remain an understudied area, despite an association between improved cognitive functions, healthier lifestyle, and greater well-being (Henry et al., 2015; Llewellyn et al., 2008; WHO, 2011). Well-being and self-perception are distinct constructs often associated together (Pinquart, 1998). Whereas self-perception is mainly linked to a cognitive evaluation of one's self and life, well-being can be defined as a positive evaluation of one's life associated with positive feelings, such as happiness. (Rosenberg, 1979; Kozma et al., 1991). Since older adults appear to benefit cognitively from such activity, developing a program targeting emotional improvement and well-being could be relevant.

Furthermore, even when there was no association between improvement in cognition (MoCA and visuospatial memory), and better SPA, future studies could target more specific cognitive skills hypothesized as contributing to poor self-views and stereotyping. For example, poor executive control was linked to the expression of stereotyping and behavioural discrimination (Payne, 2005). Executive control is the capacity to constrain thought processes and behaviours to reach goals. It includes abilities with planning, monitoring behaviour, flexibility to coordinate behaviour in complex, new, or ambiguous situations; selecting the relevant information that facilitates one's goal while actively inhibiting information that interferes, and overriding automatic and impulsive responses when they do not match with goals (Baddeley, 1998; Norman & Shallice, 1986). It is possible that cognitive training targeting one or the other of these cognitive abilities could be efficient at reducing NAS and improving SPA.

In the present study, the implicit impact of physical or cognitive training as the only strategy was insufficient to improve NAS. Participants may have changed how they perceived their aging selves, but their views of older adults and aging, in general, appeared stable over time. In other words, participating in such training could potentially change how one perceives oneself, but not how one perceives older adults in the world around them. In this study, we were curious about the impact of experiencing abilities contradictory to NAS (e.g., engaging in physical activity is incoherent with a NAS suggesting frailty in older adults) to change NAS endorsement explicitly and implicitly.

However, in the process of stereotyping, different factors contribute to the adherence to stereotyping despite new experiences. Consistent with Weiner's attribution theory (Weiner, 1980, 1985, 2006), Brandt and Reyna (2011) explored the attributional component of stereotypes influencing attitudes and behaviours, including stability, locus (internal or external), and controllability. Anderson et al. (1996) proposed the stable qualities suggested by stereotypes, which may contribute to older adults viewing the stereotyped behaviours as chronic and difficult to extinguish. Swim and Sanna (1996) provided evidence of stereotypes' underlying stability. They suggested that when targets were successful on tasks consistent with a stereotype, the success was attributed to internal-stable causes, and when they were successful at a stereotype-inconsistent task, success was attributed to an unstable internal cause (Jackson et al., 1993; Swim & Sanna, 1996). It is possible that our participants may have attributed their cognitive or physical progress to the development of their abilities through training (internal-stable). In contrast, they could have interpreted improvement in other participants as dependable on their effort (internal-unstable).

Stereotypes may also involve internal versus external causes for older adults' group outcomes. In most cases, stereotypes imply characteristics internal to a group (e.g., frailty, sickness, decline, wisdom), resulting from a long-lasting learning process about group members, as suggested by the stereotype embodiment theory (Levy, 2009). Finally, stereotypes may convey controllable (e.g., the decline in aging is due to the NAS's lack of openness to new experiences) or uncontrollable causes (e.g., with aging comes decline) (Brandt & Reyna, 2011). Taken together, attributions may contribute to maintaining NAS despite new experiences such as physical or cognitive training. Age stereotype-based interventions involving direct psychoeducation about these attributions while providing reliable information about aging may promote positive perceptions of aging and enhance well-being and quality of life (see for a review Knight et al., 2021)

Conclusion

Persevering in ageist behaviours has been shown for decades to be detrimental at the individual and societal levels. Power imbalances prevent older adults from realizing their full potential and contributing to the great good. In 2016, the World Health Organization received a mandate to fight ageism. One field of research focused on policy and legal interventions to target institutionalized ageism, and another targeted interventions at the individual level to change the self-perception of aging (SPA). The results of this paper show that older adults may develop better views of their aging process with training despite their NAS stable endorsement.

Developing a positive image of aging is coherent with the actual view of the aging process, which is a developmental one in nature. Interventions supporting this process at the individual level are necessary, and part of the social transformation needed in our societies. From an early age, people face phases where adjustments are required, linked to developmental tasks to undergo, promoting learning, change, and the continuity of life, which allows people the privilege of aging. By making older adults more aware and improving their perception, they could learn to navigate this developmental stage with more psychological empowerment, serenity, and well-being.

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Integrated Discussion

This chapter will summarize the two research projects composing this thesis, with results, strengths, and limitations to be discussed within theoretical and empirical literature. This section will also reflect on implications for mental health and neuropsychology, and social strategies for better aging will be addressed. Finally, specific contributions to advancing knowledge in the aging field with recommendations for future research projects are presented.

Summary of the Two Research Projects

Both articles fall within the context of promoting better aging, including access to reliable health sector services and intervention options supporting adjustments and well-being in older years. Therefore, the first set of objectives related to improving older adults' cognitive assessment by 1) exploring the implicit and explicit NAS and SPA on older adults' performance on clinical tests and 2) studying the relationship between NAS and SPA, and visuospatial memory and processing speed. The second set of objectives related to intervention and included 3) investigating the impact of two types of physical training (fitness and gross-motor abilities) and cognitive training on NAS endorsement and SPA, and 4) studying whether any improvements in NAS and SPA would covary with improvement in cognition attributed to physical or cognitive training. The hypotheses were 1) higher implicit/explicit NAS would negatively correlate with cognitive tests scores, whereas better SPA and better self-perceived competency of cognitive performance would correlate positively with cognitive tests scores; 2) Implicit/explicit NAS would predict cognitive tests scores including negative effect sizes whereas SPA would predict cognitive scores with positive effect sizes; 3) Explicit and implicit NAS would explain variance in cognitive scores after controlling for demographic measures (age and education), cognitive abilities known as contributing to the cognitive score and self-relevance (self-perceived competency and the degree of which the individual values cognitive performance), 4) through training, SPA would improve and NAS endorsement would decrease among participants, and 5) SPA would improve as a function of better cognition or fitness.

Confirming the hypotheses, results from the first study showed that 1) higher explicit NAS negatively correlated with verbal and visuospatial memory and processing speed, 2) explicit NAS predicted processing speed after controlling for age, education, cognitive abilities and perception of competency, 3) explicit NAS predicted delayed visuospatial memory after accounting for age and education, and 4) Implicit NAS predicted verbal memory after accounting for explicit NAS. However, SPA had no relationship with any cognitive scores. Results from the second study aligned with our hypothesis, which suggested that a 3-month regimen of either training type would lead to improvements in SPA. On the other hand, NAS remained stable, contrary to our expectations. Finally, SPA improvements were independent of better fitness and cognition, limiting the interpretation drawn from the link between improved SPA and training.

Investigating the Effects of Negative Aging Stereotypes on Older Adults' Cognitive Performance: Methodology, Results, and Future Directions

Participants were tested in a realistic clinical environment, promoting performance while aligning with professionals' ethics. This included considerations for the physical milieu, therapeutic alliance, and use of standardized clinical measures of cognition. This was important to address limitations in the generalization of research to clinical settings and the underlying assumptions that clinical measures could be protected from NAS effects. Clinicians would avoid making comments triggering stress in their examinees and use tests rarely included in this field of research.

The results further support and extend findings coming from the literature. Higher levels of NAS did interfere not only with performance on clinical verbal memory measures but also with clinical tests of processing speed and visuospatial memory, even once controlling for age and education. Research has extensively targeted verbal memory performance as an area vulnerable to NAS threat. Furthermore, to our knowledge, exploring how NAS related with clinical measures was rarely done in research. However, our results align with the literature supporting that NAS impedes performance in various cognitive domains. Not only in Memory (Armstrong et al., 2017; Chasteen et al., 2005; Kang & Chasteen, 2009) but also in non-specific cognitive tasks such as math tests (Abrams et al., 2008), crossword tasks (Swift et al., 2013), letter cancellation task (Popham & Hess, 2013) and block design task (Hehman & Bugental, 2013). Furthermore, NAS was shown to interfere with physical tasks, such as walking speed, flexibility (Horton et al., 2010) and grip strength (Lamont, 2011; Swift et al., 2012), or skills acquisition, such as learning to use a new computer-based library cataloging system (Fritzsche et al., 2009), driving skills (Joanisse et al., 2013) and screening measures (Mazerolle et al., 2016). Findings on Working memory are relatively mixed (Armstrong et al., 2017), although here again, this domain was understudied compared to memory. However, many studies did find that NAS activation reduced working memory performance in older adults (Fernandez-Ballesteros et al., 2015; Hess & Hinson, 2006), whereas other studies did not show such impediment (Hess et al., 2009; Popham & Hess, 2015). In the case of our research, NAS endorsement did not show to be related to participants' working memory performance.

According to Forbes's model of stereotype threat processes, stereotype activation during the performance could affect controlled processing due to elevated physiological response, increased task monitoring, and attempts to suppress negative emotion. Consequently, cognition is depleted, and working memory capacity and the ability to perform tasks requiring controlled processing are thought to be reduced (Lamont et al., 2015). According to this model, when a stereotype is activated, a cascade of events co-occurs, reducing cognitive resources for the task at hand.

Unfortunately, preventing all stereotype threats from happening in social interaction and a social milieu may not be realistic. Our results suggest that a threat can occur in older adults despite examiners' good intentions and professional behaviours in session. Here, there was no need to intentionally trigger a stereotype in older adults to see their performance impeded. People's endorsement of long-lasting negative beliefs about aging was enough. However, an unintended threat may have been present since they are hypothesized to arise from any situational cue indicative of one's risk of being judged based on negative stereotypes about their social identity. Even when a target of the threat is unaware of the source of the threat (Steele, 1997), when one's group identity, a social context in which the stigma is present, self-relevant, and could be confirmed, is enough to interfere with the individual's performance (Steele & Aronson, 1995). As Steele (1997) suggested, stereotypes are "in the air," invisible, but always present. It is reasonable to hypothesize that being evaluated on cognitive abilities and competencies constitutes a setting favourable to triggering a threat for older adults. As Lamont et al. (2015) suggested, since ageism toward older people is widely accepted and endemic in subtle forms (Nelson, 2002), it may be challenging to distinguish intentions behind actions toward older people. Even at the hands of well-intentioned people, older adults may be at risk of being cued with NAS. Research has already reported the impeding effect of using patronizing voices on older adults' well-being (Draper, 2005) and how NAS activation could increase help-seeking behaviours, thus creating more dependency in social interactions (Coudin & Alexopoulos, 2010).

Although more research is needed, it appears that in its various forms, a combination of older adults' internalized NAS, subtle cues coming from the clinical setting, and professionals' own NAS endorsement combined are at risk of negatively impacting older individuals' performance during a cognitive assessment. It is, therefore, crucial in future studies to extend on types of interventions that have shown promising results in reducing threats during a performance.

Stereotype threat interventions. Most laboratory interventions have worked to reduce the effect of stereotype threat with reconstrual intervention, coping interventions, or creating identity-safe environments (Spencer et al., 2016).

The reconstrual intervention. This intervention reduces stereotype threat by leading the individual to perceive a lower threat level. Altering the description of a test is a way that has shown a reduced threat reflected in performance. For example, when students participating in a mathematics class were told that the test did not show gender differences, women's performance improved significantly (Good et al., 2008).

In aging, presenting a memory task as an orientation task or an age-fair task also improved memory performance (Bouazzaoui et al., 2015; Desrichard & Köpetz, 2005; Mazerolle et al., 2012). However, providing a false test description may not always be practical in the real world (Spencer et al., 2016). Another way to change individuals' perception of a threat is the reconstrual of their experience. This can be reached by helping people to reappraise their anxiety (Johns et al., 2008), by linking stereotype traits with positive abilities (Kray et al., 2002), or by reminding characteristics shared with the nonthreatened group (Rosenthal & Crisp, 2006; Rosenthal et al., 2007). However, this type of intervention assumes individuals' good insight and stereotype awareness, and it is suggested that threats can occur without awareness and perceived stress in examinees (Schmader et al., 2008). Despite these limitations, reconstrual manipulation showed promising results for reducing underperformance in women (Good et al., 2008), black students (Aronson et al., 2002; Walton & Cohen, 2007), and older adults (Bouazzaoui et al., 2015; Desrichard & Köpetz, 2005; Mazerolle et al., 2012).

Coping interventions. This type of intervention can provide examinees with tools to address stress during the performance. For instance, educating people about stereotype threats and the illegitimacy of stereotypes could restore performance (Johns et al., 2005). Self-affirmation reached by stating values or self-attributes before a stressful task could help restore self-integrity (Steele, 1988) and improve performance (Sherman et al., 2013). Self-affirmation training among older adults was shown to be effective in reducing negative emotions and enhancing self-integrity (Dang et al., 2021).

Similarly, Follenfant and Atzeni (2020) have provided promising results of individuation intervention to alleviate stereotype threat in the clinical assessment of memory. Before a memory task, the participants completed a questionnaire about themselves (e.g., leisure activities, values, and personality traits). This individuation intervention allowed participants to disconnect the self from their aging identity and memory performance, promoting their results.

The creation of identity-safe environments. This means the modification of a physical and relational milieu to alleviate threats. This was done by facilitating positive contact with members of the majority group (Walton et al., 2014) and by providing role models of successful group members (Drury et al., 2011; Shaffer et al., 2013), or by having group members administer the test (McGlone et al., 2006). Although for decades, psychosocial researchers have identified novelty, unpredictability, low sense of control, and threat to one's ego as four situational determinants eliciting physiological stress in an environment (Dickerson & Kemeny, 2004; Mason, 1968; Sindi et al., 2013). In cognitive aging, these situational determinants may be experienced differently by younger and older individuals (Lupien et al., 2007). Familiarity with testing location, same-age examiners, morning schedule for testing, and adapting task instructions showed decreased stress levels and better memory performance in older adults (Sindi et al., 2013). In our study, results suggest that NAS was negatively related with performance despite creating a safe environment for identity. However, the examiners were indeed younger adults who could have threatened the participants' egos. Future intervention studies could target this aspect, as age is not a manipulable variable, thus not generalizable to clinical settings.

Recommendations. Neuropsychologists can provide an in-depth understanding of the interplay between brain and behaviour relationships, social skills, and personality functioning. Measures of anxiety and mood states are routinely part of the neuropsychological battery in which qualitative information is also noted, such as level of motivation, alertness, and collaboration in sessions. This information is essential to provide a psychological context and to prevent misdiagnosing cognitive impairments due to an undetected temporary state of depression, mild psychiatric conditions, lack of motivation, or acute stress during testing (Sachdev et al., 2013). Given the extensive findings on the impact of NAS on cognitive performance and considering our results, we argue that NAS should be added to the battery when testing older adults. This questionnaire should be included at the very end of the assessment to prevent triggering NAS before a performance. Finally, stereotype threats should be assumed to occur in the testing room, despite all means deployed to offer a safe environment. Mental health professionals working with older adults would benefit from developing intervention skills to address these NAS.

Exercising your Perception of Aging: Methodology, Results, and Futures Directions

In this project, improved SPA did not mean making participants feel, look or be younger but was defined as developing a more realistic view of one's life at this given stage of aging (Kotter-Grühn, 2015). A perception that would distance from social views of aging, which are most stereotyped and handicapping. Aging is a developmental phase that includes various trajectories. Socially shared beliefs about aging lead people to narrow their perceptions of aging, with expected decrementing, limiting, and declining courses. The objective was to provide older adults with an experience of health-related behaviours and empowerment through interventions, not *despite* their age but *with* their age and their life courses. Of course, physical or cognitive intervention programs aiming at challenging NAS and improving SPA need to be replicable, accessible, and practicable if they were to be offered in the community. Our interventions were built to be engaging to older adults and represent a space in which they could experience empowerment, health, and well-being. The format also included frequency, intensity, and length of training, as well as measures of improvement over time, based on methodologies developed in exercise science and psychology of cognition.

If SPA did not interfere with cognitive performance, it was the measure improved by the training, despite unchanged NAS endorsement. SPA tended to improve in physical exercise groups and to remain stable in the cognitive training group without a statistically significant group effect. Our results align with the emerging literature supporting an association between improved SPA and exercising behaviours (Brothers & Diehl, 2017; Hausdorff et al., 1999; Klusmann et al., 2012; Stephan et al., 2013; Wolff et al., 2014), which suggests that exercise has the potential to overcome subjective ageist bias and promote health in older adults. Furthermore, our study explored the relative impact of two different exercise types on SPA. Although this needs replication, our results suggest that cardiovascular-based and gross-motor-based programs could be as efficient. Developing knowledge about different types of exercise could be relevant when considering older adults' interests and abilities.

Without being statistically significant, we observed a tendency in which SPA improved in physical exercise groups while it remained stable over time in the cognitive training group. The idea that cognitive training may extend the targeted improved cognitive domain in non-trained domains remains highly contested. Still, cognitive training is a progressively popular non-pharmacological intervention for improving cognition in neurodegenerative diseases (Chandler et al., 2016; Dardiotis et al., 2018; Leung et al., 2015) and healthy aging (van Balkom et al., 2020), particularly for working memory and reasoning skills (Klimova, 2016). Interestingly, cognitive training has been shown to improve one's perception of daily cognitive functioning, suggesting it may enhance the psychological component of cognitive self-efficacy in healthy older adults (Goghari & Lawlor-Savage, 2018). However, since most of the studies focus on the preservation of cognitive function, psychological implications remain an understudied area, despite an association existing between improved cognitive functions and healthier lifestyle, and greater well-being (Henry et al., 2015; Llewellyn et al., 2008; World Health Organization, 2011).

Psychological intervention in older age. Many intervention studies with older people in clinics, communities, and nursing homes have reported meaningful improvements in older adults' subjective happiness (Greenawalt et al., 2019; Ho et al., 2014), life satisfaction (Mayordomo et al., 2016; Sutipan et al., 2017), and psychological well-being (Friedman et al., 2017; Ramirez et al., 2014). However, very few studies aimed at making people feel more positive about their age or aging process (Kotter-Grühn, 2015).

Self-perception is distinct from well-being, although they are often associated together (Diehl & Wahl, 2010; Pinquart, 1998). Self-perception is more related to a cognitive evaluation of one's self and life rather than a positive evaluation of one's life associated with positive feelings (Rosenberg, 1979). Promoting positive SPA was shown to be important for psychological and physical health. From about 65 years old, people tend to show age-related increases in perceptions of physical and social losses. From 55, people increasingly report fewer perceptions of ongoing development (Diehl et al., 2021). Negative self-perception was linked to poor physical health and functioning outcomes in late life, even when controlling for age, gender, partner status, residential care, number of medical conditions, self-rated health, and psychological well-being (Sargent-Cox et al., 2012). Our results suggest that SPA, a psychological construct indicator of adjustment in late life, is amenable to intervention.

Interventions for improving SPA. Favourable social comparison and psychoeducation have provided promising results in enhancing SPA. For instance, in a study by Stephan et al. (2013), older adults received feedback about their handgrip strength performance. Participants who were told they had performed better than most of their same-aged peers reported more positive SPA afterward. Similar results were obtained in a cognitive task in which older adults received social comparison feedback (Miche & Wahl, 2013). Participants reported younger subjective age when they were told that accuracy increases with age, and they made fewer mistakes than younger adults. Thus, it appears that making people aware of positive age-related changes and providing favourable social comparison feedback could be a successful strategy to change older adults' SPA.

Providing information about successful aging could also be an avenue to improve people's views of aging. For example, Wolff et al. (2014) assigned older adults to a physical activity intervention, an active control condition (volunteering), or a physical activity intervention supplemented by a psychoeducation component. This teaching part included providing information about positive aging, correcting misconceptions about aging, and the benefit of having more positive views of aging. Participants also learned how to identify automatic thoughts on aging and replace them with neutral or positive ones. Participants from this group reported improved SPA, including satisfaction with aging and confidence. It appears that the psychoeducation piece made a difference in making SPA more positive.

Our interventions worked at changing SPA implicitly through training contradicting with typical NAS. These training were meant to have older adults transform their opinion about how they can still grow physically and cognitively. The benefit of psychoeducation suggests that changing long-lasting beliefs about aging may require more concrete interventions and valid information about this developmental stage, including specific knowledge, skills, and attitudes (Songer & Breitkreuz, 2014). Once combined with an experiential intervention, such as exercise, this intervention could address cognitive and emotional barriers to better aging. There is a saying that "Experience is better than a ton of theory because it is only in experience that any theory has vital and verifiable experience" (Dewey, 1916-1995, in Bringle & Hatcher, 1999). Older adults need opportunities to be informed and experience the inaccuracy of NAS. The opportunity to directly observe and feel one's knowledge probably contributes to the benefits of intergenerational contact interventions, in addition to offering the experience of relating and connecting meaningfully between intergroup. Such context allows individuals to be seen and understood beyond this compartimentalized box called age that we all seem to flip into overnight.

Limitation. Participants were healthy and independent individuals committed to travelling to the laboratory and exercising physically and cognitively. This population does not reflect the specific population referred for cognitive assessment in the mental health sector. NAS endorsement and SPA may likely differ individually with health state and daily functioning abilities. Some individuals may perceive their symptoms as confirming NAS and their expectations of decrement in older age. Consequently, future studies in the field could be interested in studying the impact of NAS and SPA on various individuals. Normal aging does not mean the absence of all symptoms or conditions. Since it is recognized that aging can differ individually, it is essential to know if people engaged in these various trajectories can improve their SPA and change their NAS, nevertheless. Another limitation relates to state anxiety in session. There was no measure included in the battery. Anxiety is known to interfere with cognitive performance. The interpretation of the relationship between performance and NAS could have been more robust by including this measure at the end of the assessment. Finally, adding a control group in the intervention design could have helped to evaluate the benefit of engaging in a cognitive training program.

Conclusion

Aging positively was shown to be related to healthy aging, physical fitness, and cognition (Bar-Tur, 2021). At any age, even in the very old years, people are, to some extent, responsible for their quality of life (Hill, 2005). Older adults can maintain and optimize their aging experience by implementing preventive health behaviours and engaging in resources available to them to adjust to age-related changes (Bar-Tur & Malkinson, 2014). Unfortunately, socially shared beliefs about aging interfere with older adults' willingness and capacity to take on that responsibility. Until cultural or societal values such as political regulations recognize systemic ageism, and until organizations' and other social entities' policies are proven fair for all, there will be no authentic right to aging in our societies. And yet, like any stage of human development, individuals face phases of adjustments linked to developmental tasks to complete, promoting growth and the continuity of life. The field of psychology detains an opportunity to develop interventions supporting this developmental process, despite this current social context.

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Table 1. Baseline correlations for paper 1: Investigating the effects of negative age stereotypes on older adults' cognitive performance

Corrélations

		Age in years; en années	number of years for education	Sum all items; higher, do agism	Score of the test - into the electronic folder from the computer, "expressiond" ; from -1 to 1, 0 neutral	Average items 1+2+4+6+7	Average items 3+5+8+9+10	Sum all items; higher, better	MoCA with education (max : 30)	MoCA Memory subscore (max : 5)	BVMT Total 3 trials score; add trials 1+2+3	BVMT Delayed recall score	MMSE Total score (max = 30)	W4 Similarities total score (max : 36)	W4 DS Total score (forward + backward) (max : 32)	W4 DSST Total score substitution (max : 135)
Age in years; en années	Corrélation de Pearson	1	.037	.136	-.107	.050	.132	-.113	.042	.073	-.229*	-.244**	-.209*	-.157	-.012	-.226*
	Sig. (bilatérale)		.692	.145	.296	.595	.156	.226	.651	.435	.013	.008	.023	.090	.900	.014
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
number of years for education	Corrélation de Pearson	.037	1	.008	-.037	-.001	.036	.009	.078	.144	.111	.208*	.165	.524**	.157	.125
	Sig. (bilatérale)	.692		.933	.716	.995	.699	.924	.405	.122	.233	.025	.075	.000	.090	.179
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
Sum all items; higher, do agism	Corrélation de Pearson	.136	.008	1	.036	-.015	-.154	-.094	-.130	-.187*	-.190*	-.219*	-.045	-.090	-.097	-.280**
	Sig. (bilatérale)	.145	.933		.724	.873	.097	.311	.162	.044	.040	.017	.627	.333	.298	.002
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
Score of the test - into the electronic folder from the computer, "expressiond"; from -1 to 1, 0 neutral	Corrélation de Pearson	-.107	-.037	.036	1	-.063	-.047	-.048	-.209*	-.231*	-.166	-.076	-.114	-.053	-.064	-.055
	Sig. (bilatérale)	.296	.716	.724		.536	.648	.639	.039	.022	.103	.455	.265	.602	.528	.593
	N	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
Average items 1+2+4+6+7	Corrélation de Pearson	.050	-.001	-.015	-.063	1	.339**	-.110	.071	.012	.115	.056	.038	-.005	.080	.072
	Sig. (bilatérale)	.595	.995	.873	.536		.000	.239	.444	.902	.218	.550	.681	.957	.389	.438
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
Average items 3+5+8+9+10	Corrélation de Pearson	.132	.036	-.154	-.047	.339**	1	.051	.122	.172	.116	.028	.016	-.036	.068	.213*
	Sig. (bilatérale)	.156	.699	.097	.648	.000		.585	.189	.063	.214	.766	.867	.699	.465	.021
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
Sum all items; higher, better	Corrélation de Pearson	-.113	.009	-.094	-.048	-.110	.051	1	-.138	-.025	-.160	-.116	-.075	-.035	-.138	-.148
	Sig. (bilatérale)	.226	.924	.311	.639	.239	.585		.139	.790	.085	.212	.422	.707	.137	.110
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
MoCA with education (max : 30)	Corrélation de Pearson	.042	.078	-.130	-.209*	.071	.122	-.138	1	.701**	.393**	.357**	.196*	.255**	.326**	.222*
	Sig. (bilatérale)	.651	.405	.162	.039	.444	.189	.139		.000	.000	.000	.034	.005	.000	.016
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
MoCA Memory subscore (max : 5)	Corrélation de Pearson	.073	.144	-.187*	-.231*	.012	.172	-.025	.701**	1	.258**	.237*	.035	.057	.051	.224*
	Sig. (bilatérale)	.435	.122	.044	.022	.902	.063	.790	.000		.005	.010	.710	.545	.583	.015
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
BVMT Total 3 trials score; add trials 1+2+3	Corrélation de Pearson	-.229*	.111	-.190*	-.166	.115	.116	-.160	.393**	.258**	1	.800**	.423**	.301**	.126	.236*
	Sig. (bilatérale)	.013	.233	.040	.103	.218	.214	.085	.000	.005		.000	.000	.001	.177	.010
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
BVMT Delayed recall score	Corrélation de Pearson	-.244**	.208*	-.219*	-.076	.056	.028	-.116	.357**	.237*	.800**	1	.349**	.299**	.097	.313**
	Sig. (bilatérale)	.008	.025	.017	.455	.550	.766	.212	.000	.010	.000		.000	.001	.296	.001
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
MMSE Total score (max = 30)	Corrélation de Pearson	-.209*	.165	-.045	-.114	.038	.016	-.075	.196*	.035	.423**	.349**	1	.333**	.225*	.177
	Sig. (bilatérale)	.023	.075	.627	.265	.681	.867	.422	.034	.710	.000	.000		.000	.015	.057
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
W4 Similarities total score (max : 36)	Corrélation de Pearson	-.157	.524**	-.090	-.053	-.005	-.036	-.035	.255**	.057	.301**	.299**	.333**	1	.378**	.166
	Sig. (bilatérale)	.090	.000	.333	.602	.957	.699	.707	.005	.545	.001	.001	.000		.000	.073
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
W4 DS Total score (forward + backward) (max : 32)	Corrélation de Pearson	-.012	.157	-.097	-.064	.080	.068	-.138	.326**	.051	.126	.097	.225*	.378**	1	.221*
	Sig. (bilatérale)	.900	.090	.298	.528	.389	.465	.137	.000	.583	.177	.296	.015	.000		.017
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117
W4 DSST Total score substitution (max : 135)	Corrélation de Pearson	-.226*	.125	-.280**	-.055	.072	.213*	-.148	.222*	.224*	.236*	.313**	.177	.166	.221*	1
	Sig. (bilatérale)	.014	.179	.002	.593	.438	.021	.110	.016	.015	.010	.001	.057	.073	.017	
	N	117	117	117	98	117	117	117	117	117	117	117	117	117	117	117

*. La corrélation est significative au niveau 0.05 (bilatéral).

**. La corrélation est significative au niveau 0.01 (bilatéral).

Sum all items;higher,better=Attitudes towards own aging scale; Sum all items; higher ageism= Fraboni scale of ageism; Score of the test expression d=Implicit association test; MoCA= Montreal cognitive assessment; MMSE= Mini-mental state examination; BVMTR= Brief visuospatial memory test revised; DS total score= Digit span; DSST= Coding

Table 2. Baseline correlations for paper 2: Exercising your perception of aging: Effects of physical and cognitive training on older adults’ perception of their own aging

Corrélations

		AnthropoAge_Pre	Education_Pre	GDS_Pre	FraboniTotal_Pre	IATATotal_Pre	OwnAgingTotal_Pre	MotivPhysValues_Pre	MotivPhysCompetency_Pre	MotivPhysTotal_Pre	MoCAStd_Pre	MoCAMemory_Pre	BVMTTotal3_Pre	BVMTDelayedRecall_Pre	BVMTRHITS_Pre	MMSE_Pre	W4Similarities_Pre	W4DigitSpanTotal_Pre	W4DSST_Pre	Vo2max_ml.min.kgRel_Pre	ECWnet2.5kJ_Pre
AnthropoAge_Pre	Corrélation de Pearson	1	-.083	-.073	.106	.014	.081	.073	.032	.062	.005	.098	-.349**	-.339**	-.092	-.384**	-.165	-.098	-.248	-.325*	.205
	Sig. (bilatérale)		.524	.579	.417	.916	.535	.576	.806	.636	.970	.454	.006	.007	.483	.002	.208	.456	.056	.011	.113
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
Education_Pre	Corrélation de Pearson	-.083	1	-.018	.085	-.138	-.064	.116	.152	.150	.120	.264*	.151	.307*	.029	.126	.496**	.129	.140	.238	.127
	Sig. (bilatérale)	.524		.892	.513	.303	.627	.373	.244	.250	.361	.040	.246	.016	.825	.332	.000	.326	.287	.064	.328
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
GDS_Pre	Corrélation de Pearson	-.073	-.018	1	.104	-.017	-.429**	-.026	-.151	-.075	.093	-.009	.065	.057	.021	-.088	.130	.079	.014	.052	.192
	Sig. (bilatérale)	.579	.892		.423	.900	.001	.840	.247	.565	.481	.944	.619	.662	.872	.499	.321	.549	.917	.691	.139
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
FraboniTotal_Pre	Corrélation de Pearson	.106	.085	.104	1	-.036	-.061	-.089	.161	.073	-.115	-.157	-.168	-.178	-.114	-.007	.095	-.116	-.182	.132	-.012
	Sig. (bilatérale)	.417	.513	.423		.789	.640	.495	.216	.575	.380	.228	.196	.171	.380	.957	.471	.377	.164	.311	.930
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
IATATotal_Pre	Corrélation de Pearson	.014	-.138	-.017	-.036	1	-.142	-.070	-.098	-.076	-.156	-.239	-.159	-.087	.053	-.049	-.093	-.061	-.198	.027	-.021
	Sig. (bilatérale)	.916	.303	.900	.789		.287	.602	.464	.570	.246	.070	.233	.515	.690	.716	.488	.651	.137	.842	.877
	N	58	58	58	58	58	58	58	58	58	57	58	58	58	58	58	58	58	58	58	58
OwnAgingTotal_Pre	Corrélation de Pearson	.081	-.064	-.429**	-.061	-.142	1	.070	.263*	.167	-.109	.007	-.212	-.150	-.072	-.100	-.057	-.111	-.272*	-.059	-.159
	Sig. (bilatérale)	.535	.627	.001	.640	.287		.590	.041	.198	.408	.955	.102	.248	.580	.444	.665	.400	.035	.654	.221
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
MotivPhysValues_Pre	Corrélation de Pearson	.073	.116	-.026	-.089	-.070	.070	1	.669**	.900**	.109	.222	.029	.082	.061	-.059	-.211	-.097	.218	.094	-.080
	Sig. (bilatérale)	.576	.373	.840	.495	.602	.590		.000	.000	.408	.085	.823	.532	.640	.649	.106	.461	.095	.469	.539
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
MotivPhysCompetency_Pre	Corrélation de Pearson	.032	.152	-.151	.161	-.098	.263*	.669**	1	.916**	-.039	.166	-.069	-.073	-.043	-.030	-.131	-.002	.190	.264*	-.272*
	Sig. (bilatérale)	.806	.244	.247	.216	.464	.041	.000		.000	.770	.201	.599	.576	.741	.821	.320	.987	.146	.040	.034
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
MotivPhysTotal_Pre	Corrélation de Pearson	.062	.150	-.075	.073	-.076	.167	.900**	.916**	1	.013	.193	-.031	-.013	.022	-.050	-.181	-.063	.215	.197	-.195
	Sig. (bilatérale)	.636	.250	.565	.575	.570	.198	.000	.000		.923	.135	.810	.924	.865	.699	.167	.630	.098	.129	.131
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
MoCAStd_Pre	Corrélation de Pearson	.005	.120	.093	-.115	-.156	-.109	.109	-.039	.013	1	.723**	.389**	.336**	.007	.045	.349**	.285*	.139	.061	-.095
	Sig. (bilatérale)	.970	.361	.481	.380	.246	.408	.408	.770	.923		.000	.002	.009	.957	.733	.007	.028	.293	.645	.471
	N	60	60	60	60	57	60	60	60	60	60	60	60	60	60	60	59	59	59	60	60
MoCAMemory_Pre	Corrélation de Pearson	.098	.264*	-.009	-.157	-.239	.007	.222	.166	.193	.723**	1	.339**	.302*	.056	-.083	.176	.078	.293*	-.068	-.213
	Sig. (bilatérale)	.454	.040	.944	.228	.070	.955	.085	.201	.135	.000		.008	.018	.666	.525	.178	.554	.023	.602	.099
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
BVMTTotal3_Pre	Corrélation de Pearson	-.349**	.151	.065	-.168	-.159	-.212	.029	-.069	-.031	.389**	.339**	1	.762**	.312*	.384**	.402**	.131	.140	.059	-.063
	Sig. (bilatérale)	.006	.246	.619	.196	.233	.102	.823	.599	.810	.002	.008		.000	.014	.002	.001	.317	.287	.651	.629
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
BVMTDelayedRecall_Pre	Corrélation de Pearson	-.339**	.307*	.057	-.178	-.087	-.150	.082	-.073	-.013	.336**	.302*	.762**	1	.293*	.301*	.383**	.090	.231	.062	.005
	Sig. (bilatérale)	.007	.016	.662	.171	.515	.248	.532	.576	.924	.009	.018	.000		.022	.019	.003	.496	.076	.636	.967
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
BVMTRHITS_Pre	Corrélation de Pearson	-.092	.029	.021	-.114	.053	-.072	.061	-.043	.022	.007	.056	.312*	.293*	1	.269*	.099	-.023	.030	-.295*	-.319*
	Sig. (bilatérale)	.483	.825	.872	.380	.690	.580	.640	.741	.865	.957	.666	.014	.022		.036	.451	.864	.822	.021	.012
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
MMSE_Pre	Corrélation de Pearson	-.384**	.126	-.088	-.007	-.049	-.100	-.059	-.030	-.050	.045	-.083	.384**	.301*	.269*	1	.253	.174	.170	.139	-.103
	Sig. (bilatérale)	.002	.332	.499	.957	.716	.444	.649	.821	.699	.733	.525	.002	.019	.036		.051	.184	.194	.287	.427
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
W4Similarities_Pre	Corrélation de Pearson	-.165	.496**	.130	.095	-.093	-.057	-.211	-.131	-.181	.349**	.176	.402**	.383**	.099	.253	1	.310*	.090	.073	.093
	Sig. (bilatérale)	.208	.000	.321	.471	.488	.665	.106	.320	.167	.007	.178	.001	.003	.451	.051		.016	.493	.580	.478
	N	60	60	60	60	58	60	60	60	60	59	60	60	60	60	60	60	60	60	60	60
W4DigitSpanTotal_Pre	Corrélation de Pearson	-.098	.129	.079	-.116	-.061	-.111	-.097	-.002	-.063	.285*	.078	.131	.090	-.023	.174	.310*	1	.221	.157	-.020
	Sig. (bilatérale)	.456	.326	.549	.377	.651	.400	.461	.987	.630	.028	.554	.317	.496	.864	.184	.016		.089	.232	.882
	N	60	60	60	60	58	60	60	60	60	59	60	60	60	60	60	60	60	60	60	60
W4DSST_Pre	Corrélation de Pearson	-.248	.140	.014	-.182	-.198	-.272*	.218	.190	.215	.139	.293*	.140	.231	.030	.170	.090	.221	1	.195	-.173
	Sig. (bilatérale)	.056	.287	.917	.164	.137	.035	.095	.146	.098	.293	.023	.287	.076	.822	.194	.493	.089		.136	.185
	N	60	60	60	60	58	60	60	60	60	59	60	60	60	60	60	60	60	60	60	60
Vo2max_ml.min.kgRel_Pre	Corrélation de Pearson	-.325*	.238	.052	.132	.027	-.059	.094	.264*	.197	.061	-.068	.059	.062	-.295*	.139	.073	.157	.195	1	-.070
	Sig. (bilatérale)	.011	.064	.691	.311	.842	.654	.469	.040	.129	.645	.602	.651	.636	.021	.287	.580	.232	.136		.593
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61
ECWnet2.5kJ_Pre	Corrélation de Pearson	.205	.127	.192	-.012	-.021	-.159	-.080	-.272*	-.195	-.095	-.213	-.063	.005	-.319*	-.103	.093	-.020	-.173	-.070	1
	Sig. (bilatérale)	.113	.328	.139	.930	.877	.221	.539	.034	.131	.471	.099	.629	.967	.012	.427	.478	.882	.185	.593	
	N	61	61	61	61	58	61	61	61	61	60	61	61	61	61	61	60	60	60	61	61

**. La corrélation est significative au niveau 0.01 (bilatéral).

*. La corrélation est significative au niveau 0.05 (bilatéral).

GDS= Geriatric depression scale; Own aging total=Attitudes towards own aging scale; Fraboni= Fraboni scale of ageism; IATAT=Implicit association test; MoCA= Montreal cognitive assessment; MMSE= Mini-mental state examination; BVMTR= Brief visuospatial memory test revised; DSST= Coding; ECW= Energy cost of walking;Vo2max_ml.min.kgRel.Pre=Vo2Peak

Table 3. Change scores correlations for paper 2: Exercising your perception of aging: Effects of physical and cognitive training on older adults' perception of their own aging

Corrélations

		AnthropoAge_Pre	Education_Pre	Change_FSA	OA_change	Change_IAT	Change_Value_Phys	Change_Competency_Phys	Change_Motivation_Phys	MoCA_change	BVMTR_change	ECW_change	Vo2peak_residuals
AnthropoAge_Pre	Corrélation de Pearson	1	-.083	.317*	.115	.061	.104	.081	.049	-.093	-.064	.116	-.102
	Sig. (bilatérale)		.524	.013	.376	.658	.434	.542	.710	.484	.629	.378	.433
	N	61	61	61	61	56	59	59	59	59	60	60	61
Education_Pre	Corrélation de Pearson	-.083	1	-.176	.131	-.214	.105	.239	.177	.249	.140	.289*	.035
	Sig. (bilatérale)	.524		.174	.315	.112	.426	.068	.180	.057	.286	.025	.789
	N	61	61	61	61	56	59	59	59	59	60	60	61
Change_FSA	Corrélation de Pearson	.317*	-.176	1	-.013	.126	-.082	-.038	-.080	-.036	-.163	-.148	-.203
	Sig. (bilatérale)	.013	.174		.920	.357	.538	.775	.545	.785	.215	.261	.117
	N	61	61	61	61	56	59	59	59	59	60	60	61
OA_change	Corrélation de Pearson	.115	.131	-.013	1	-.036	.381**	.085	.316*	.040	.203	-.191	-.010
	Sig. (bilatérale)	.376	.315	.920		.791	.003	.523	.015	.763	.121	.143	.942
	N	61	61	61	61	56	59	59	59	59	60	60	61
Change_IAT	Corrélation de Pearson	.061	-.214	.126	-.036	1	.032	-.194	-.127	-.086	.047	.059	.054
	Sig. (bilatérale)	.658	.112	.357	.791		.816	.161	.362	.531	.728	.665	.695
	N	56	56	56	56	56	54	54	54	55	56	56	56
Change_Value_Phys	Corrélation de Pearson	.104	.105	-.082	.381**	.032	1	.557**	.877**	-.015	.066	.009	.011
	Sig. (bilatérale)	.434	.426	.538	.003	.816		.000	.000	.912	.621	.948	.934
	N	59	59	59	59	54	59	59	59	57	58	58	59
Change_Competency_Phys	Corrélation de Pearson	.081	.239	-.038	.085	-.194	.557**	1	.838**	.113	-.089	.044	.027
	Sig. (bilatérale)	.542	.068	.775	.523	.161	.000		.000	.402	.507	.745	.840
	N	59	59	59	59	54	59	59	59	57	58	58	59
Change_Motivation_Phys	Corrélation de Pearson	.049	.177	-.080	.316*	-.127	.877**	.838**	1	.033	.020	.059	.062
	Sig. (bilatérale)	.710	.180	.545	.015	.362	.000	.000		.807	.881	.662	.640
	N	59	59	59	59	54	59	59	59	57	58	58	59
MoCA_change	Corrélation de Pearson	-.093	.249	-.036	.040	-.086	-.015	.113	.033	1	.206	.010	-.128
	Sig. (bilatérale)	.484	.057	.785	.763	.531	.912	.402	.807		.117	.940	.336
	N	59	59	59	59	55	57	57	57	59	59	59	59
BVMTR_change	Corrélation de Pearson	-.064	.140	-.163	.203	.047	.066	-.089	.020	.206	1	.090	.206
	Sig. (bilatérale)	.629	.286	.215	.121	.728	.621	.507	.881	.117		.496	.115
	N	60	60	60	60	56	58	58	58	59	60	60	60
ECW_change	Corrélation de Pearson	.116	.289*	-.148	-.191	.059	.009	.044	.059	.010	.090	1	.229
	Sig. (bilatérale)	.378	.025	.261	.143	.665	.948	.745	.662	.940	.496		.078
	N	60	60	60	60	56	58	58	58	59	60	60	60
Vo2peak_residuals	Corrélation de Pearson	-.102	.035	-.203	-.010	.054	.011	.027	.062	-.128	.206	.229	1
	Sig. (bilatérale)	.433	.789	.117	.942	.695	.934	.840	.640	.336	.115	.078	
	N	61	61	61	61	56	59	59	59	59	60	60	61

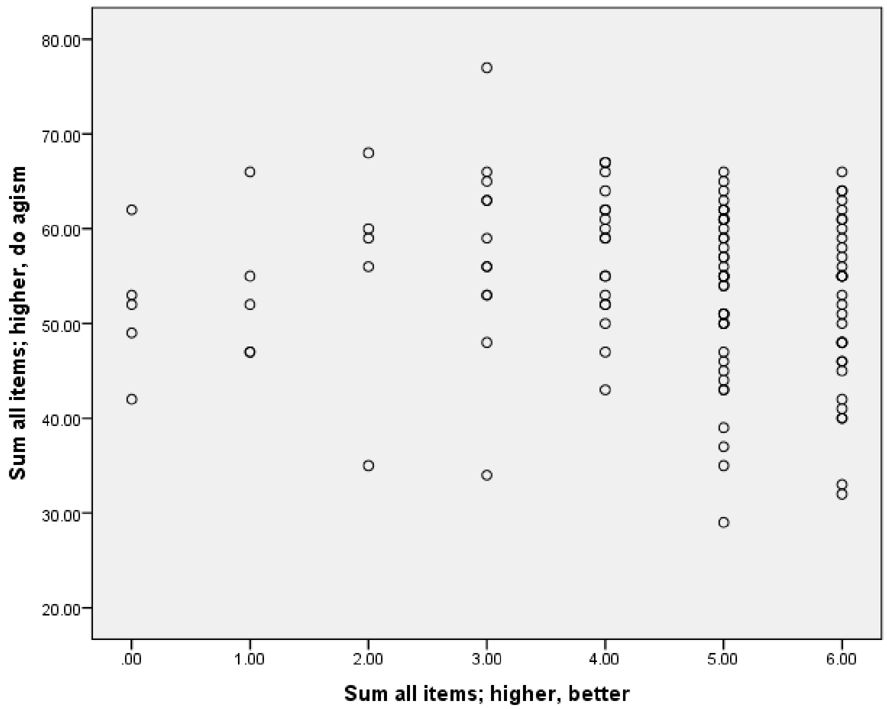
*. La corrélation est significative au niveau 0.05 (bilatéral).

**. La corrélation est significative au niveau 0.01 (bilatéral).

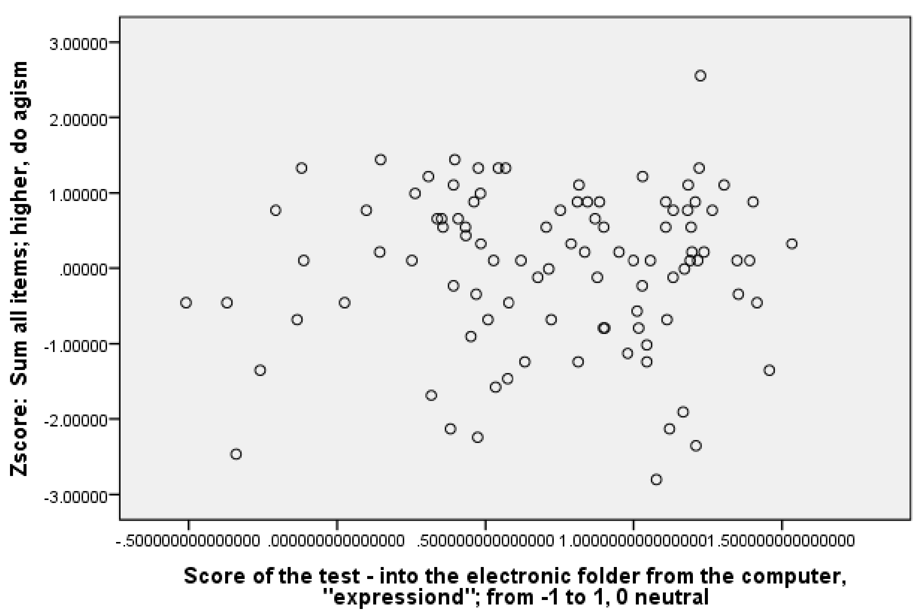
OA=Attitudes towards own aging scale; FSA= Fraboni scale of ageism; IAT=Implicit association test; MoCA= Montreal cognitive assessment; BVMTR= Brief visuospatial memory test revised; ECW= Energy cost of walking

Figure 1. Scatterplots with main predictors

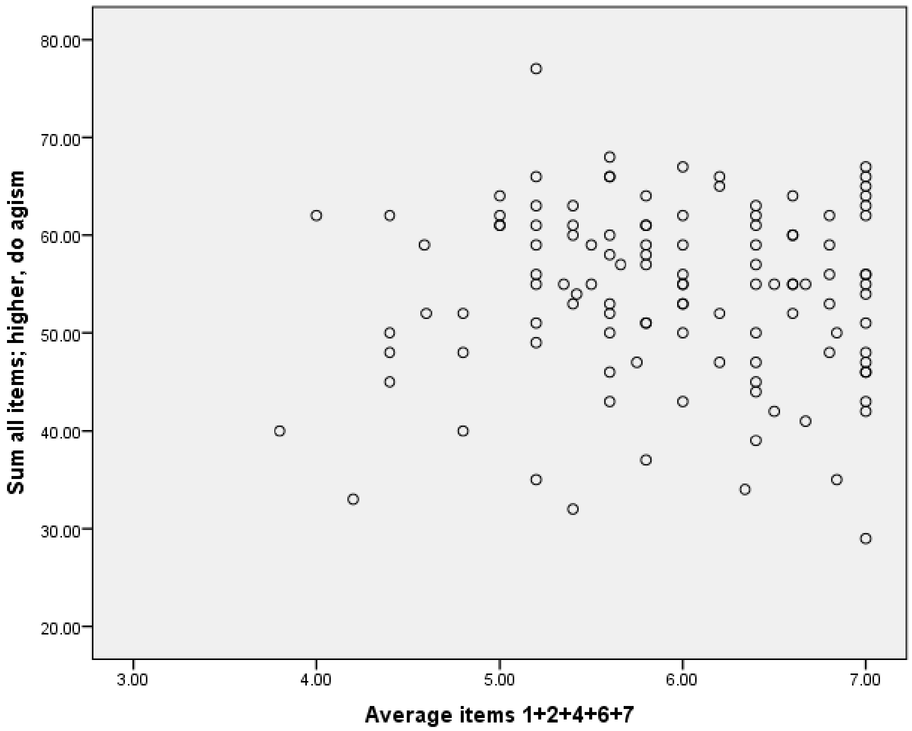
Fraboni Scale of Ageism (Y) & Attitudes Towards Own Aging (X)



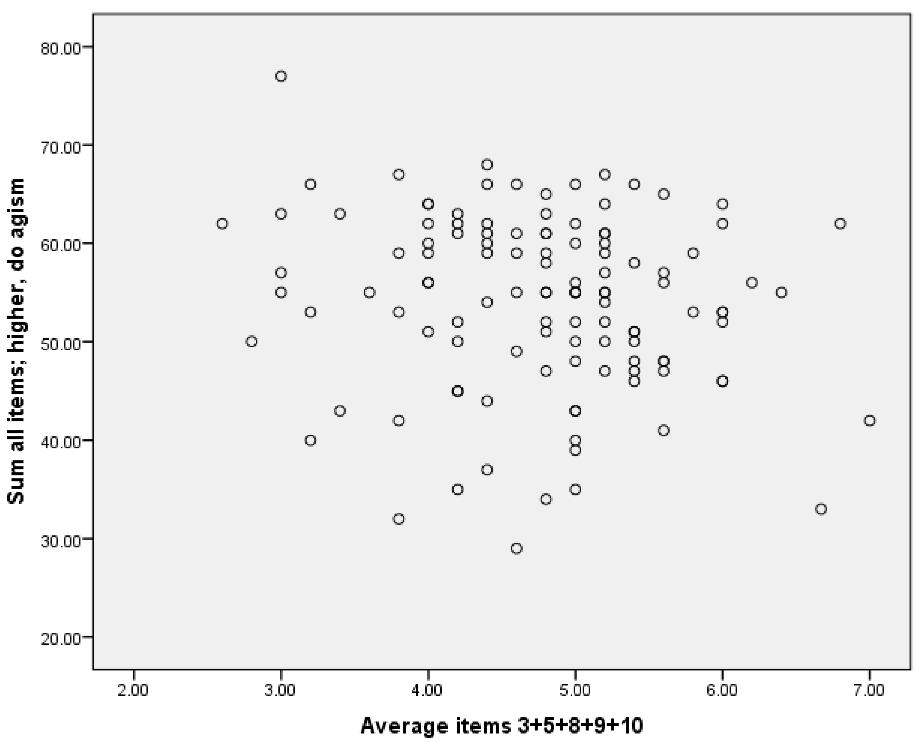
ZFSA (Y) & Implicit Association Test (X)



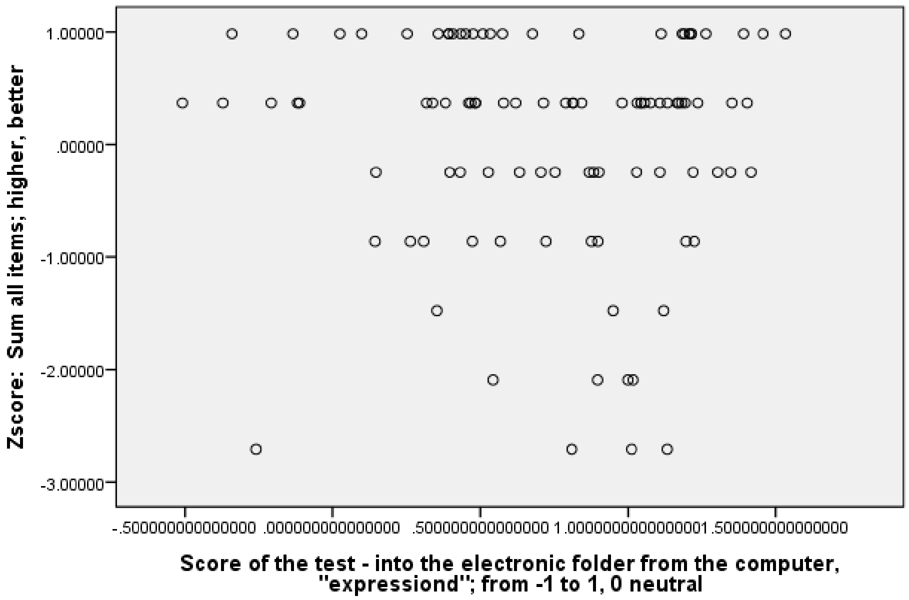
FSA (Y) & Value Cognition (X)



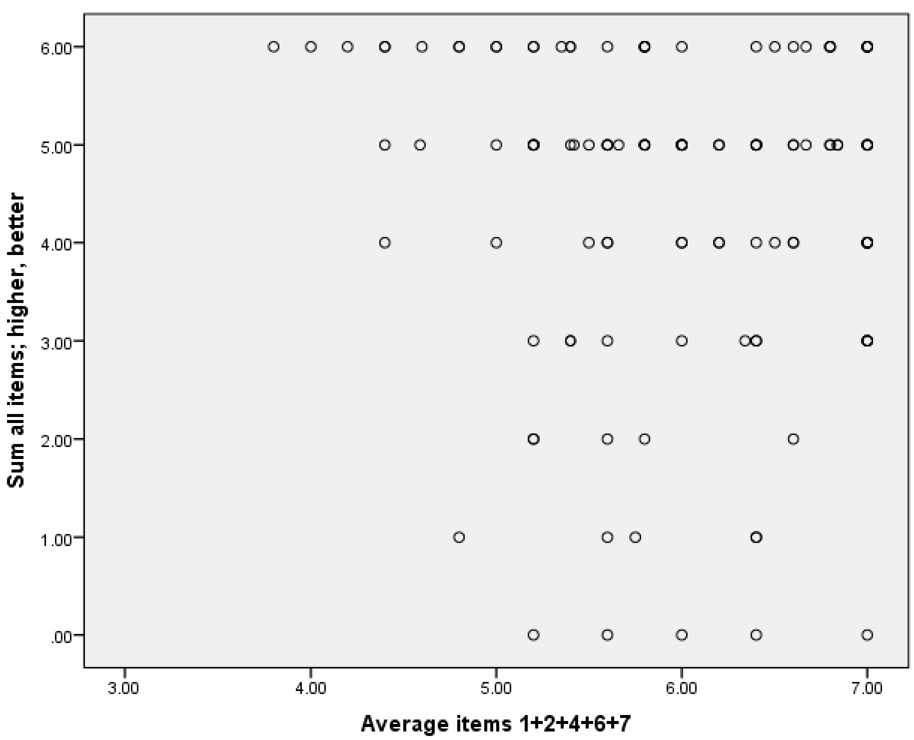
FSA (Y) & Competency Cognition (X)



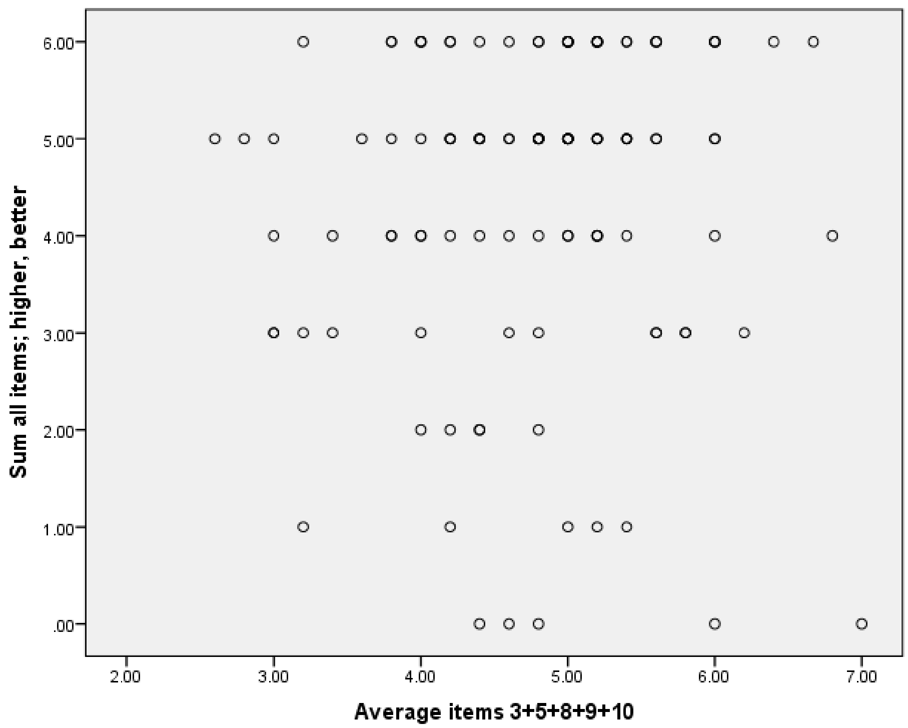
ZATOA (Y) & IAT (X)



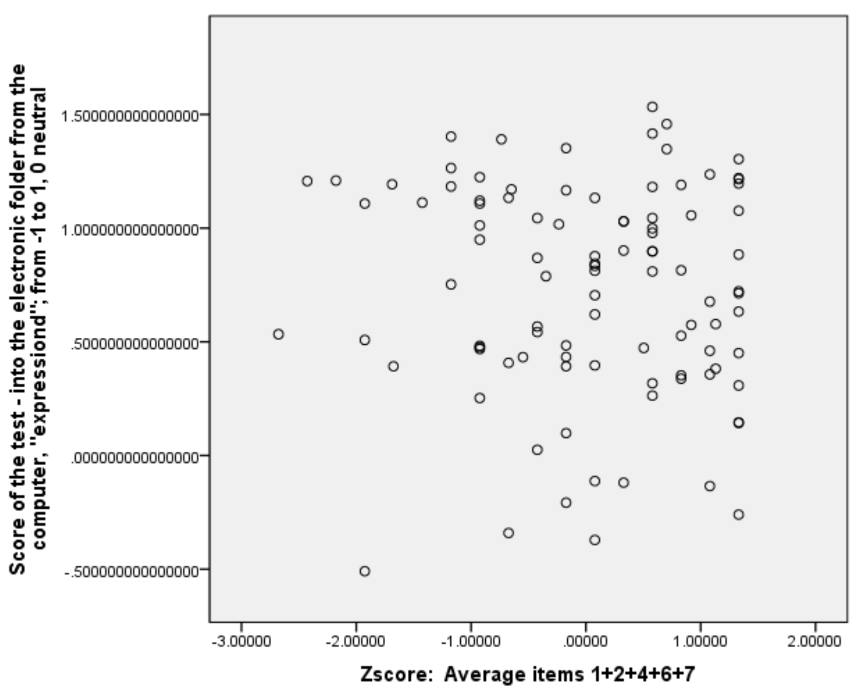
ATOA (Y) & Value Cognition (X)



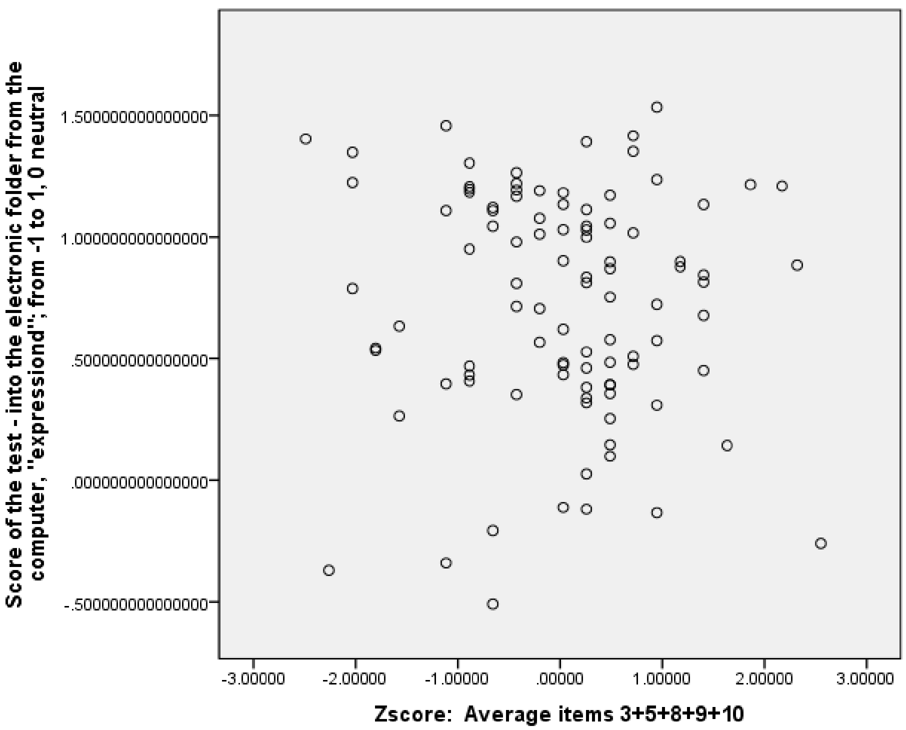
ATOA (Y) & Competency Cognition (X)



IAT (Y) & Zvalue Cognition (X)



IAT (Y) & Zcompetency Cognition (X)



Value Cognition (Y) & Competency Cognition (X)

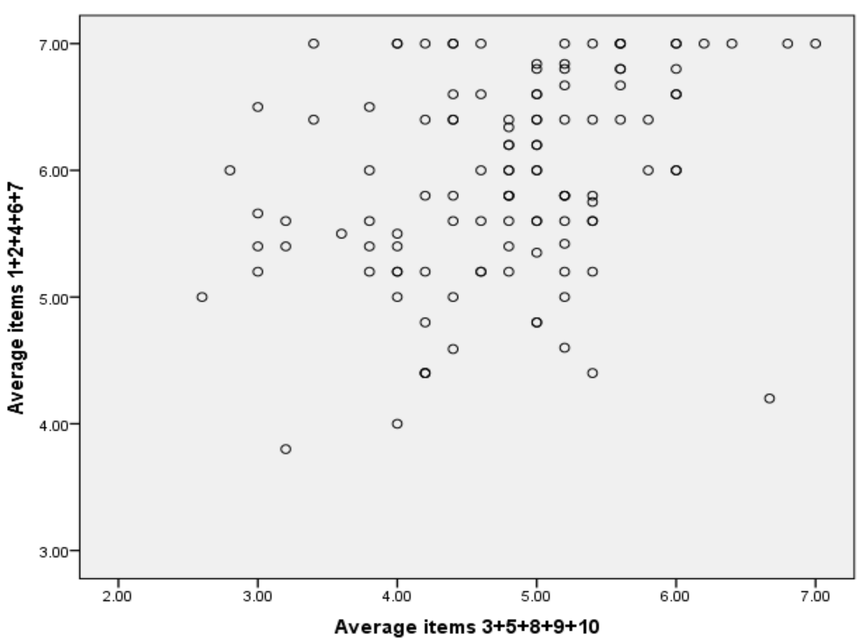
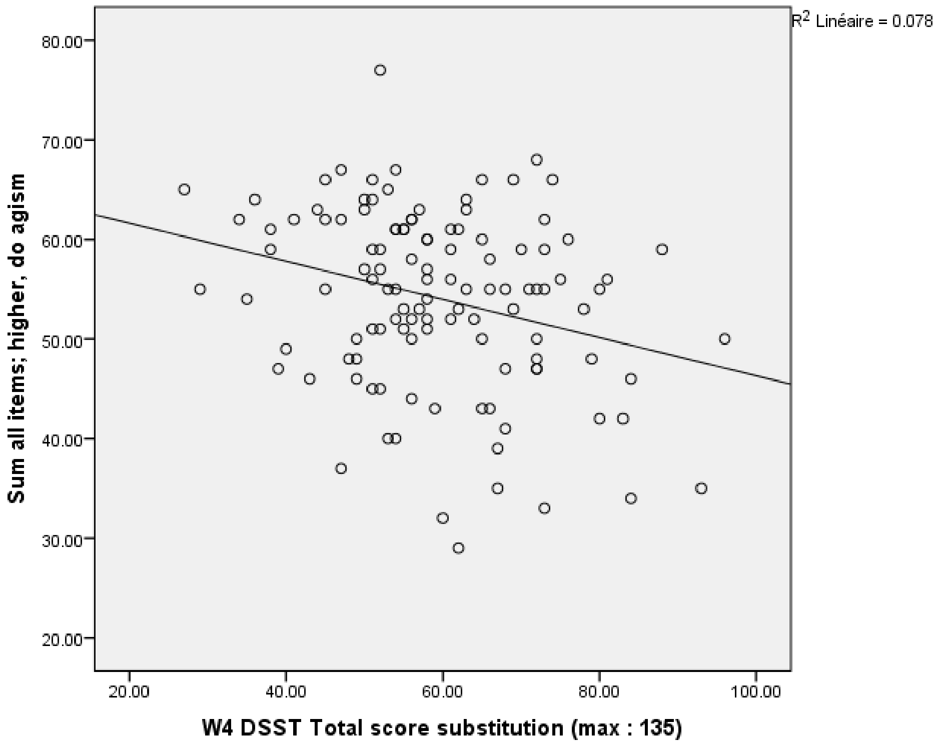
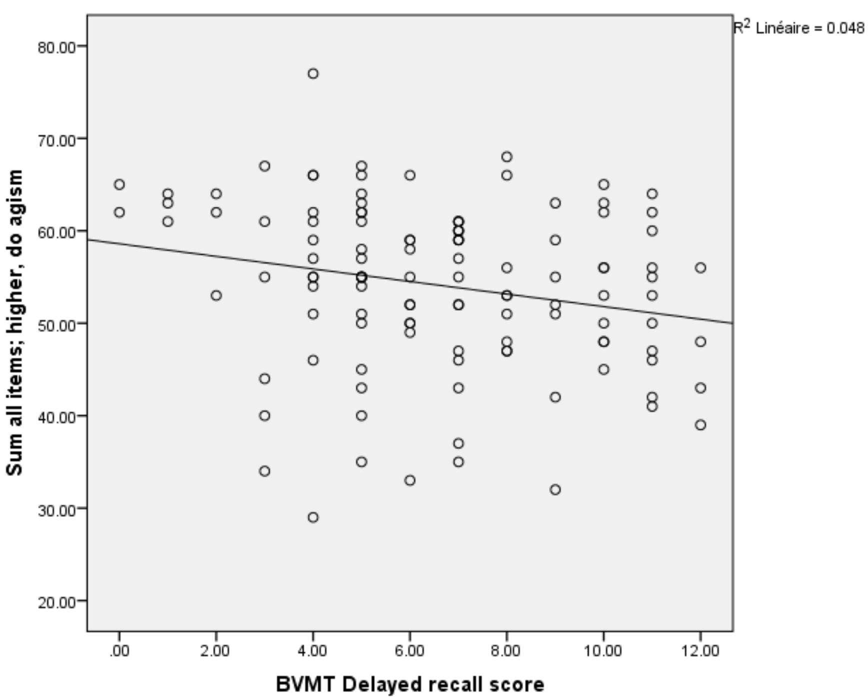


Figure 2. Scatterplots for Regressions

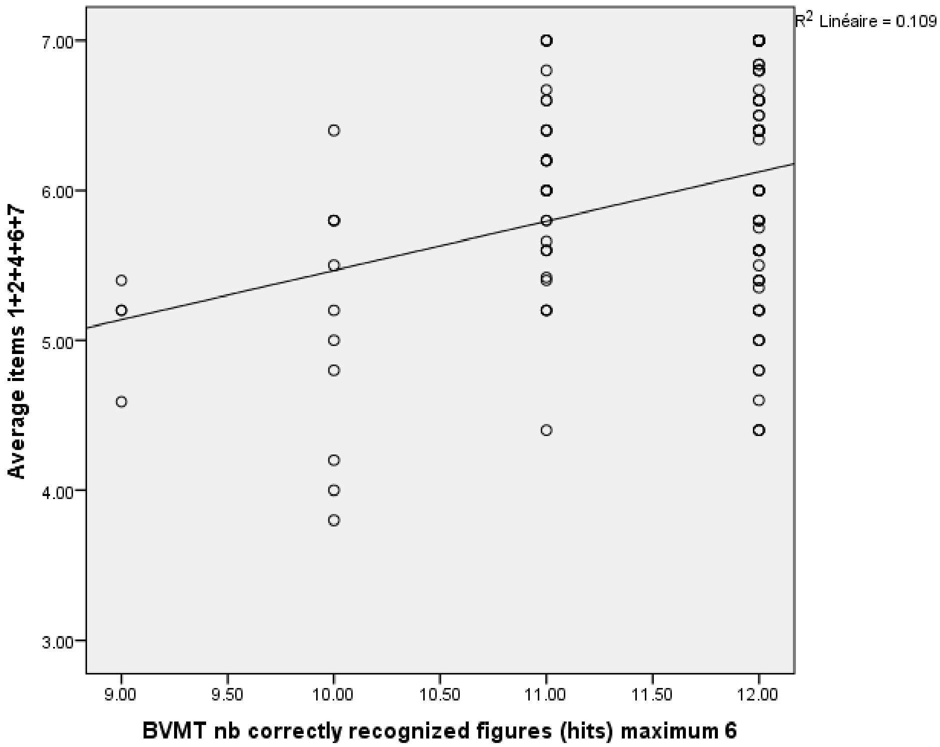
Model 1 FSA (Y) predicts Coding (X)



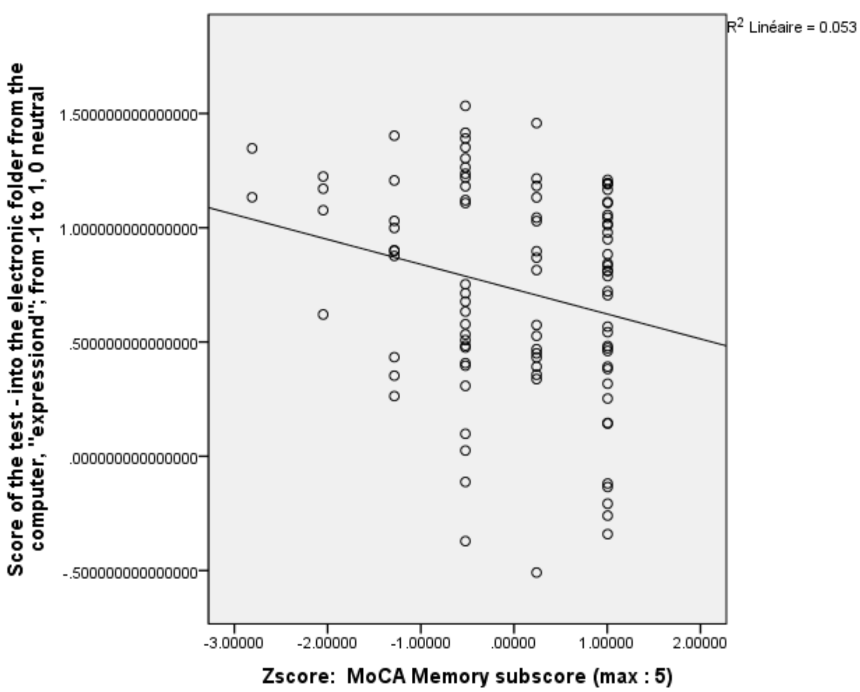
FSA (Y) predicts BVMTR delayed (X)



Value (Y) predicts recognition (X)



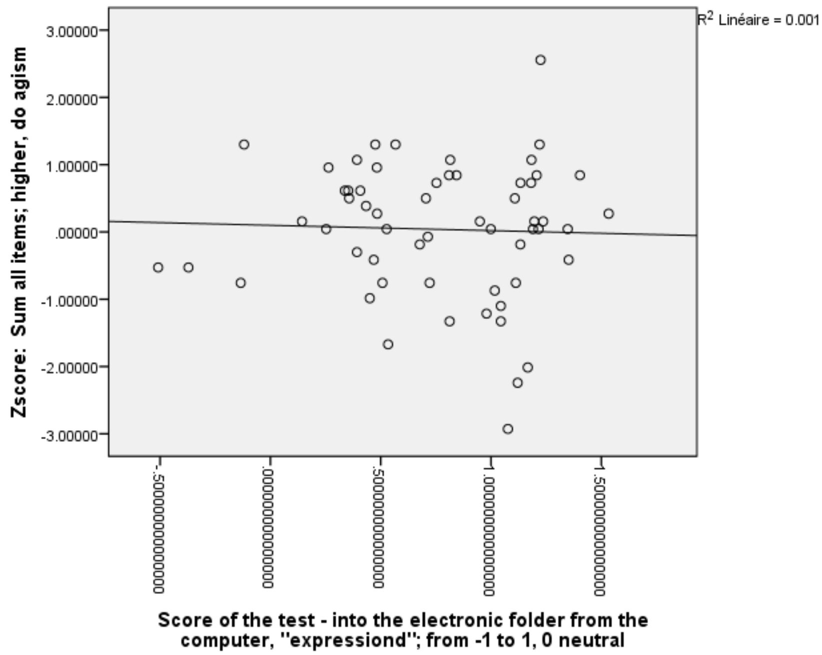
IAT (Y) predicts Zmemory MoCA (X)



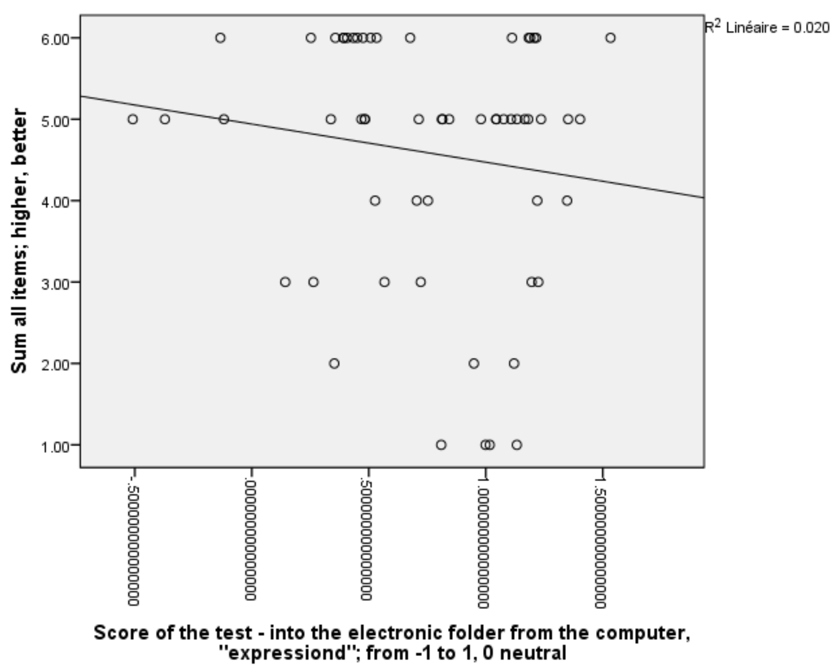
Paper 2 Exercising your Perception of Aging: Effects of Physical and Cognitive Training on Older Adults' Perception of their Own Aging

Figure 1 Scatterplots baseline measures

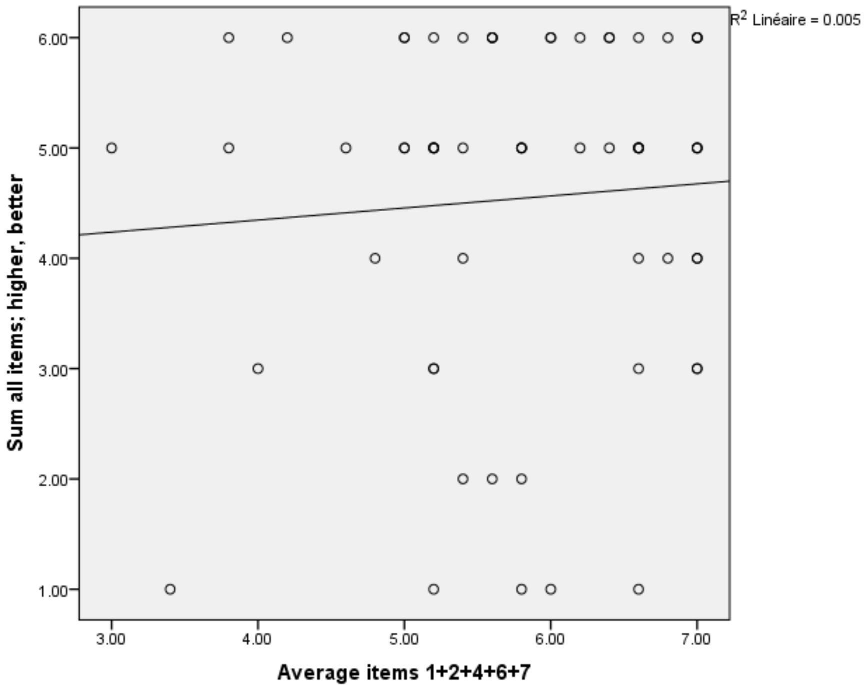
FSA (Y) & IAT (X)



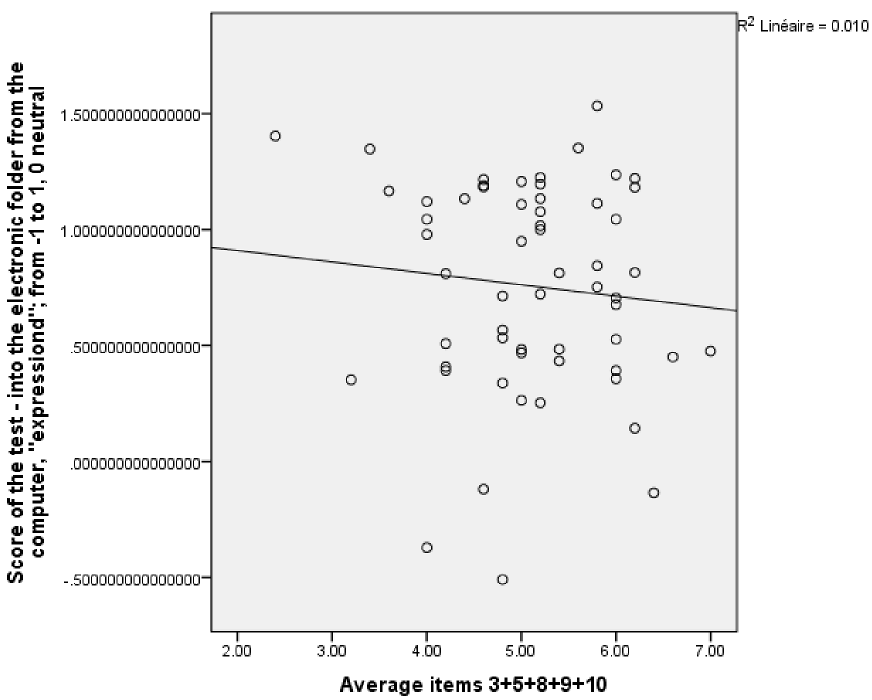
ATOA (Y) & IAT (X)



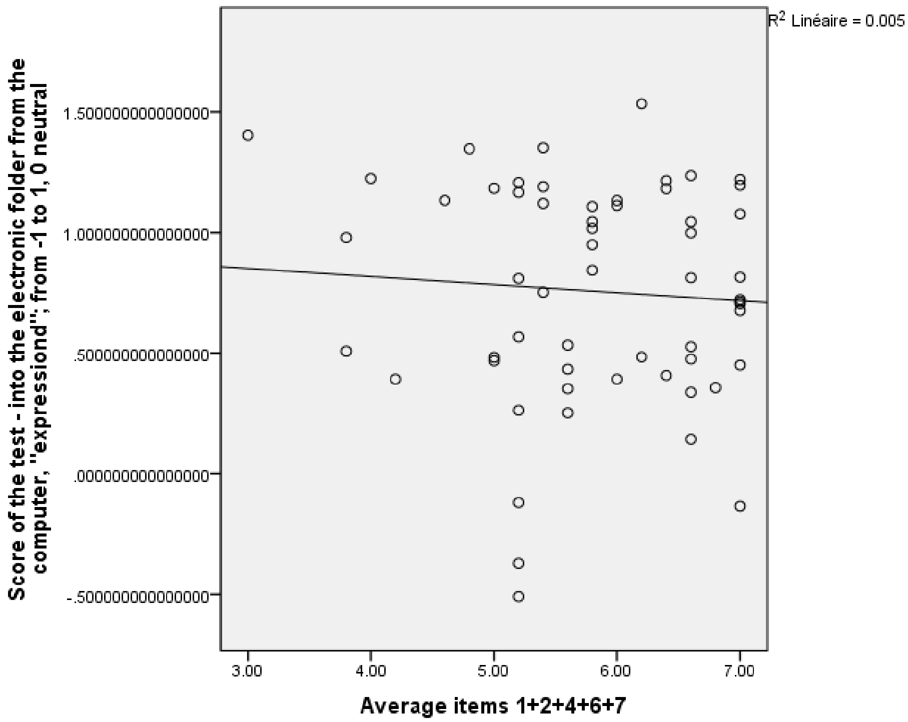
ATOA (Y) & Value Physical (X)



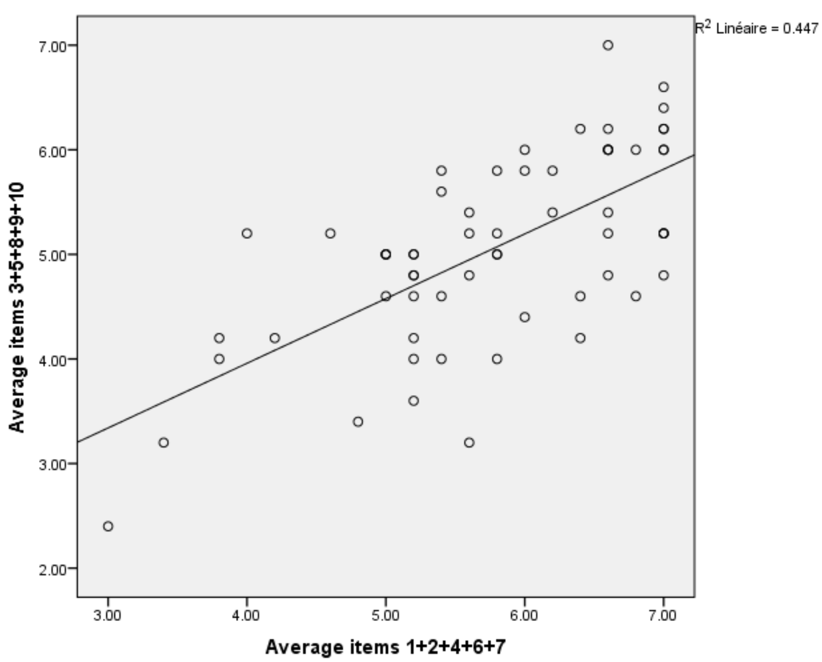
IAT (Y) & Competency Physical (X)



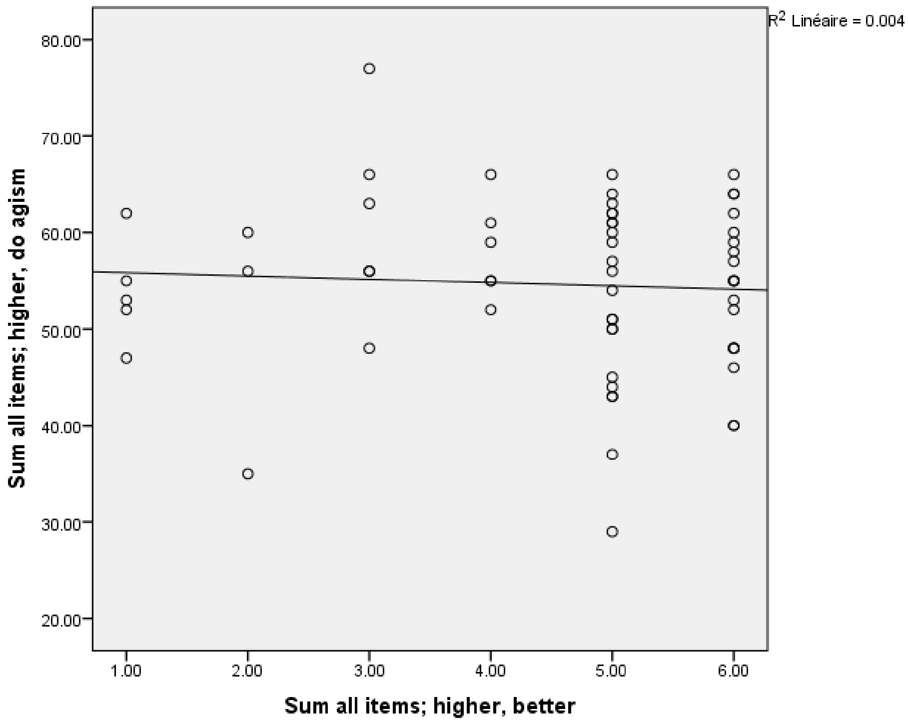
IAT (Y) & Value Physical (X)



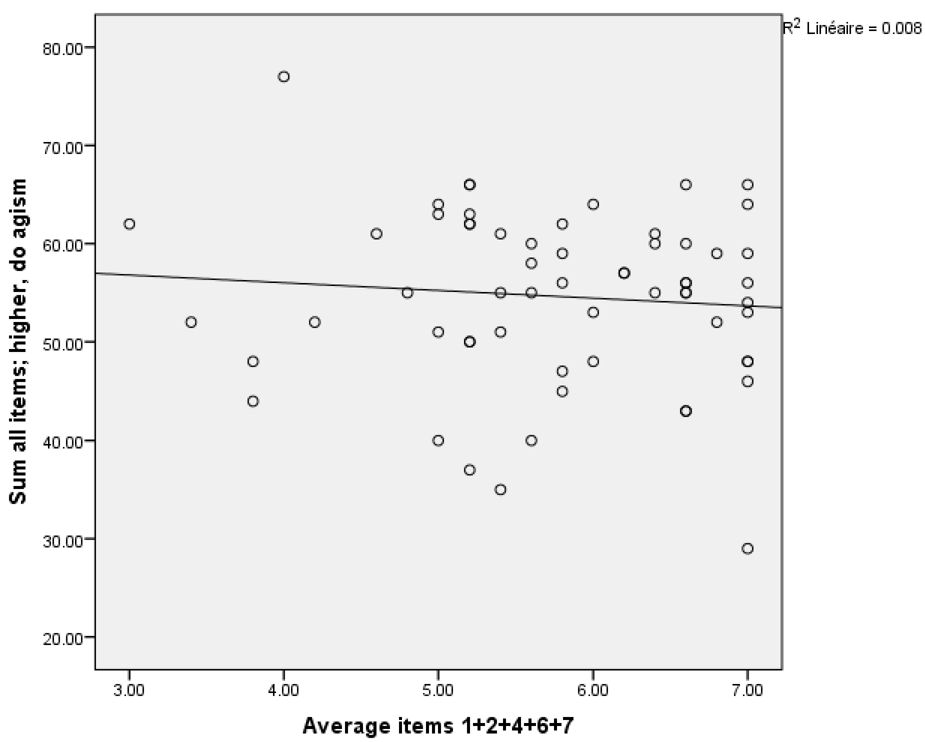
Value Physical (Y) & Competency Physical (X)



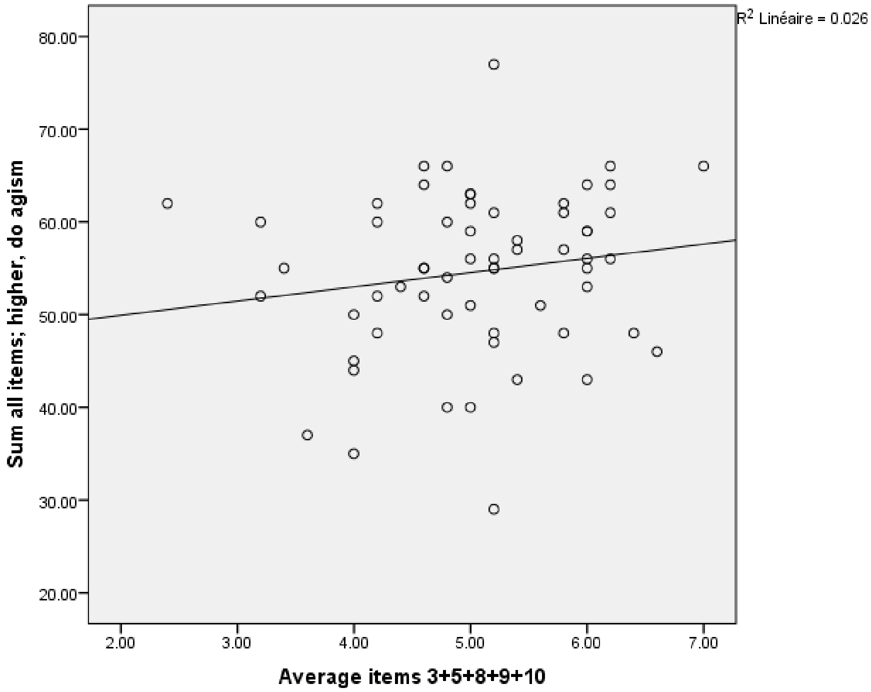
FSA (Y) & ATOA (X)



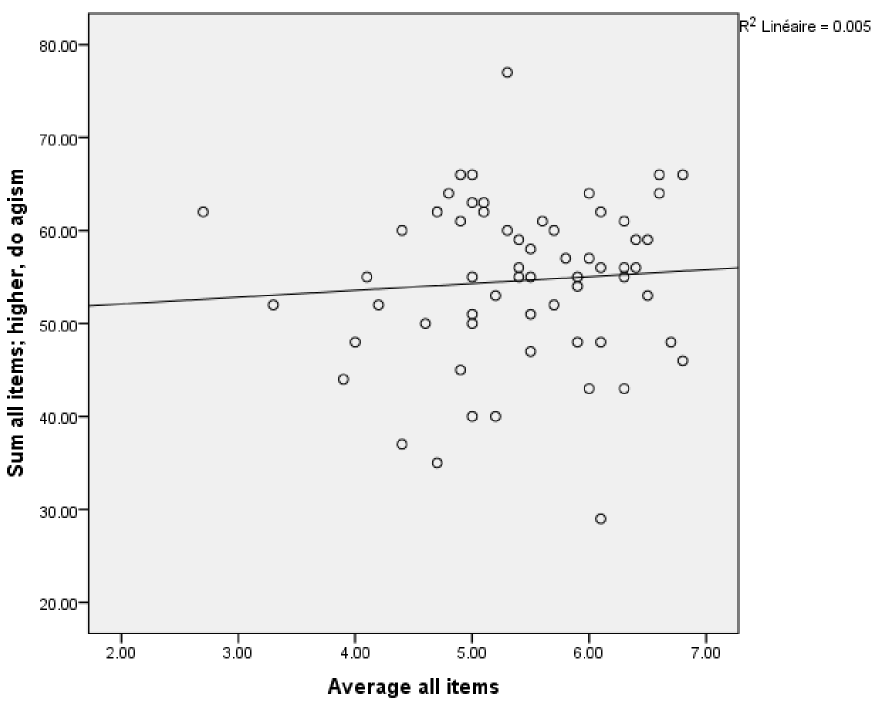
FSA (Y) & Value Physical (X)



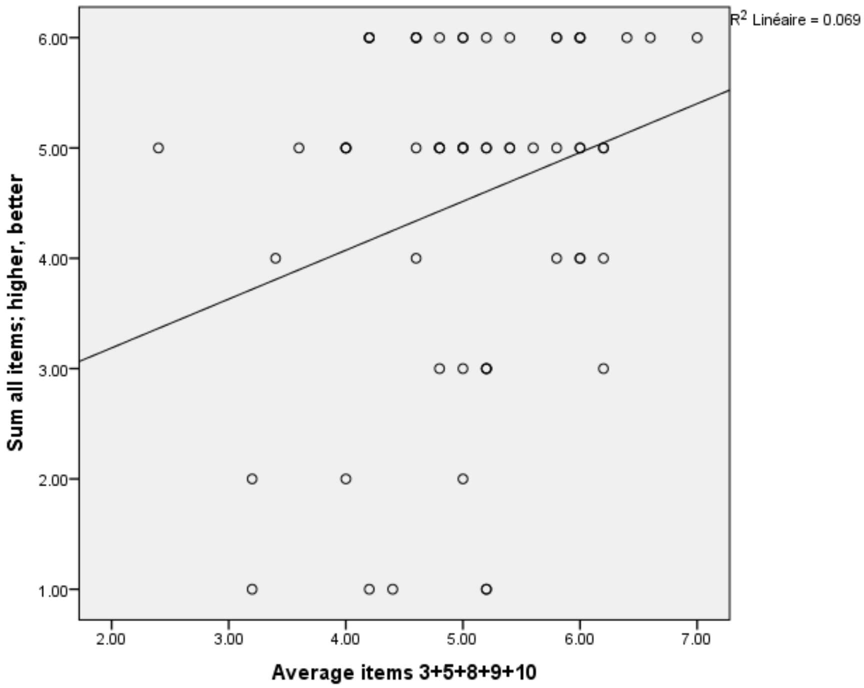
FSA (Y) & Competency Physical (X)



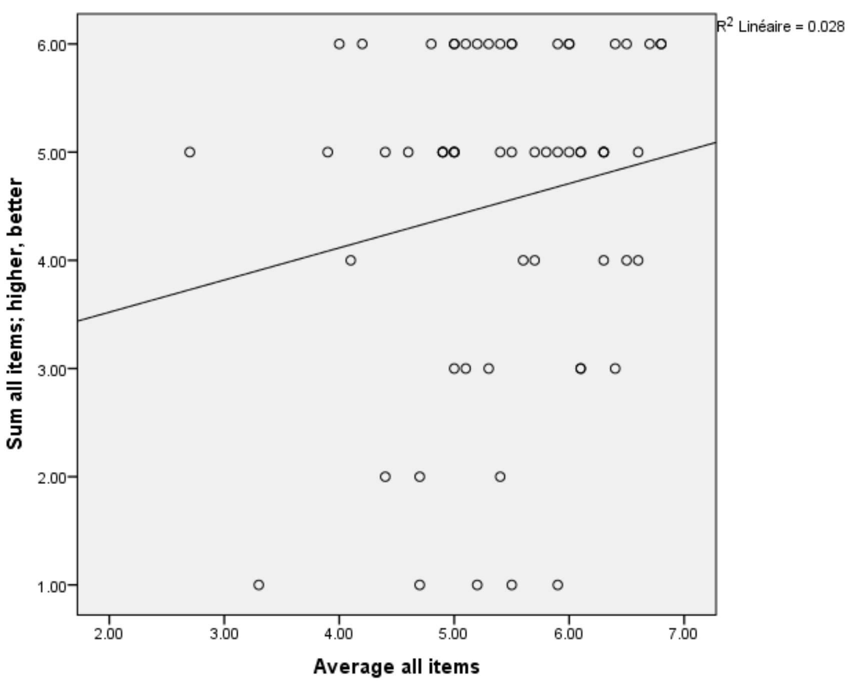
FSA (Y) & Motivation Physical Total (X)



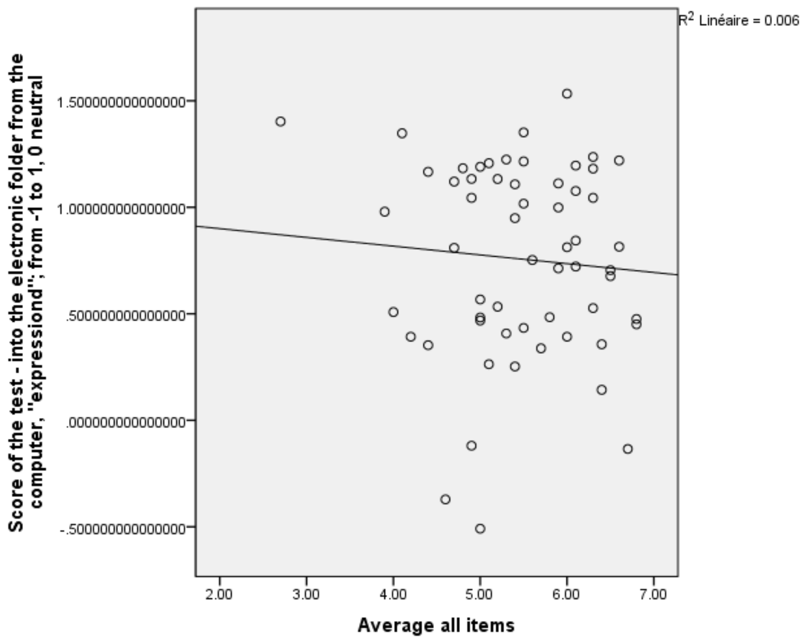
ATOA (Y) & Competency Physical (X)



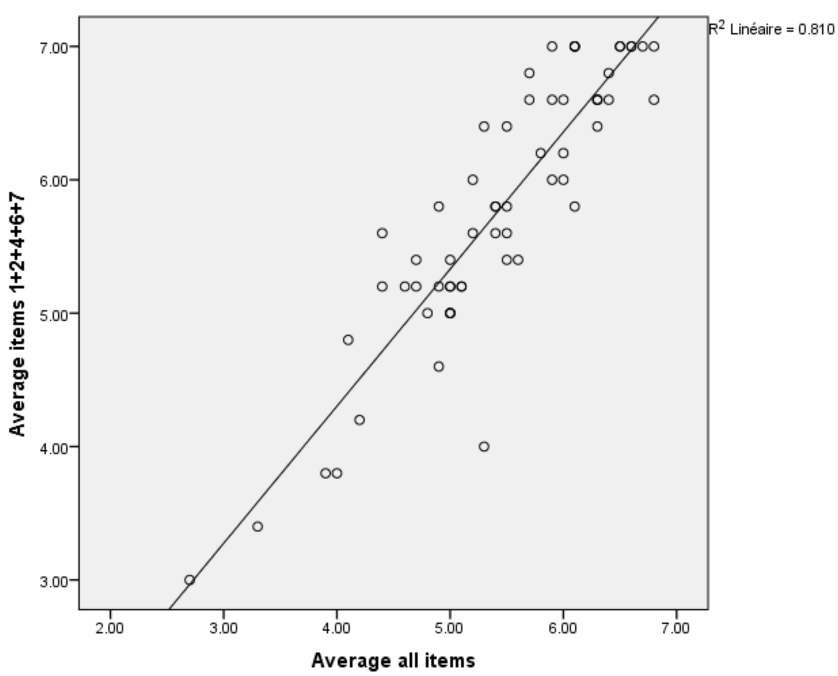
ATOA (Y) & Motivation Physical Total (X)



IAT (Y) & Motivation Physical Total (X)



Value Physical (Y) & Motivation Physical Total (X)



Competency Physical (Y) & Motivation Physical Totalm(X)

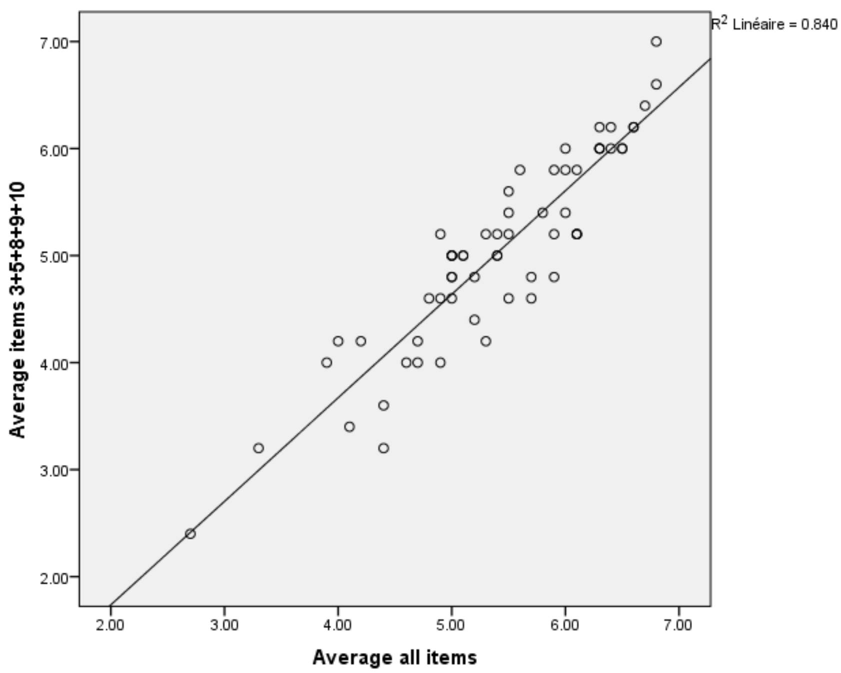
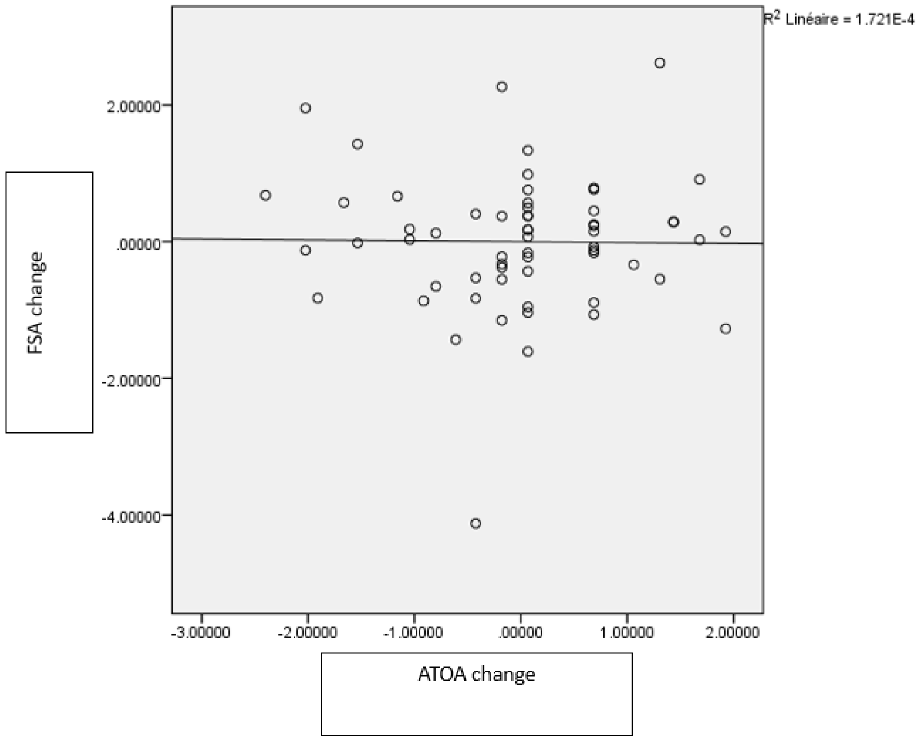
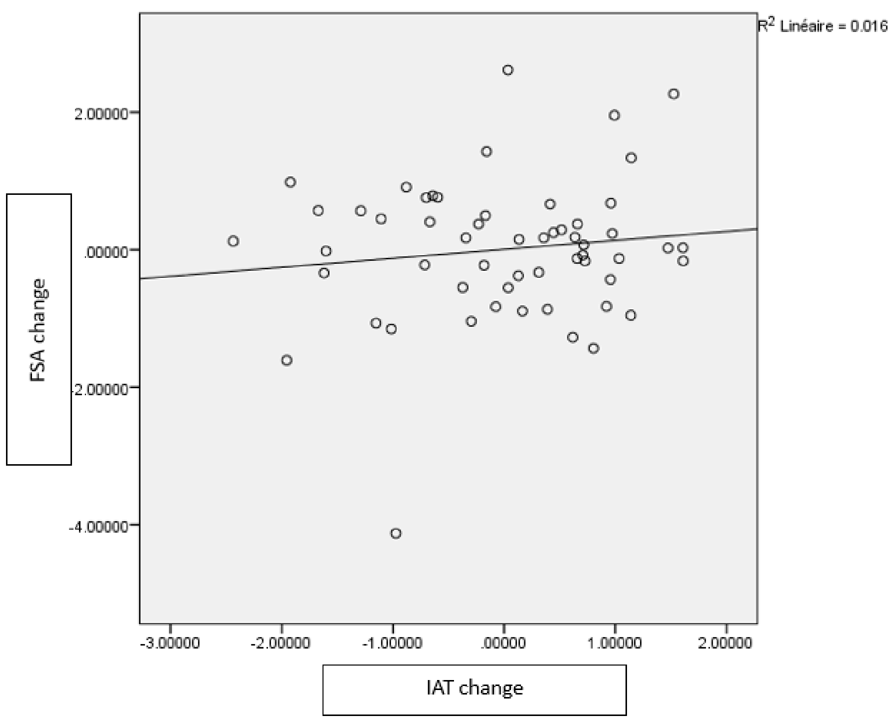
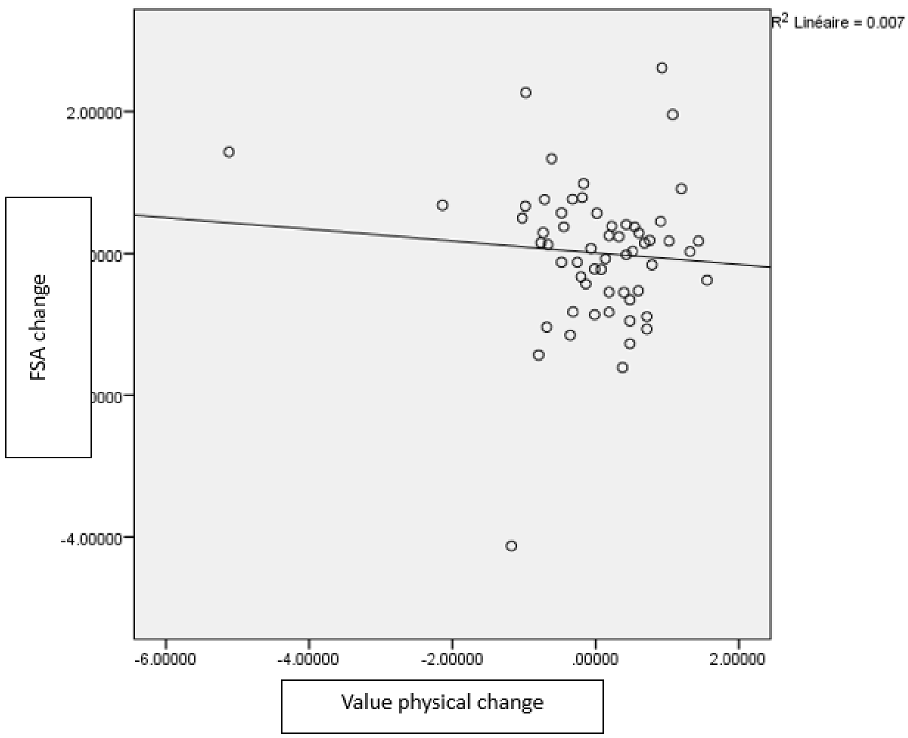
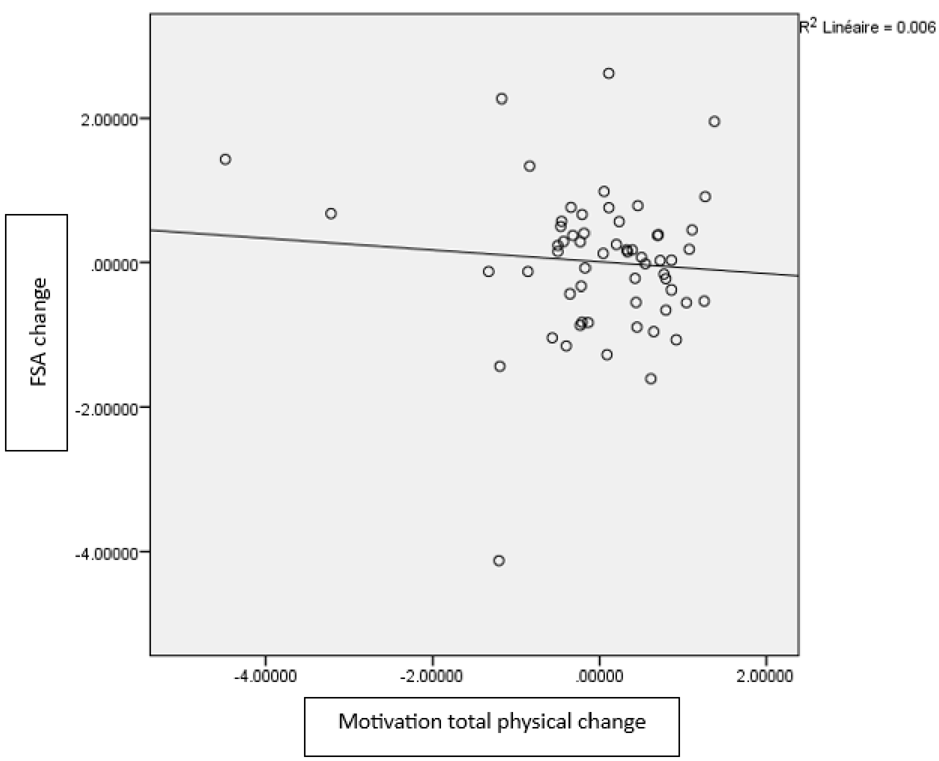


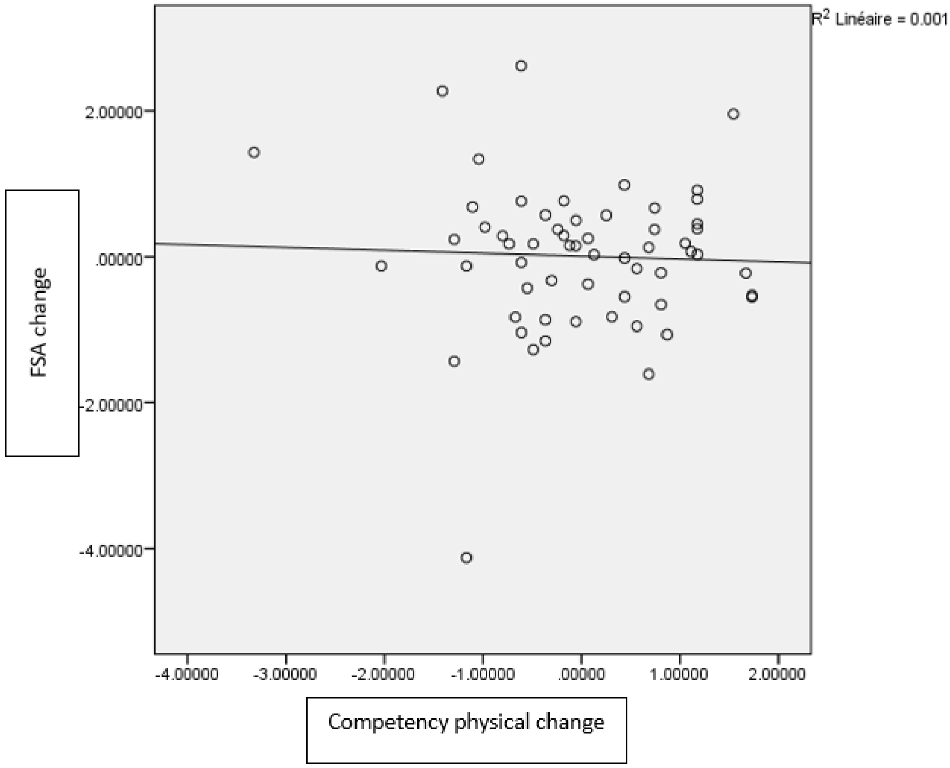
Figure 2. Scatterplots for Change scores (pre-post intervention)

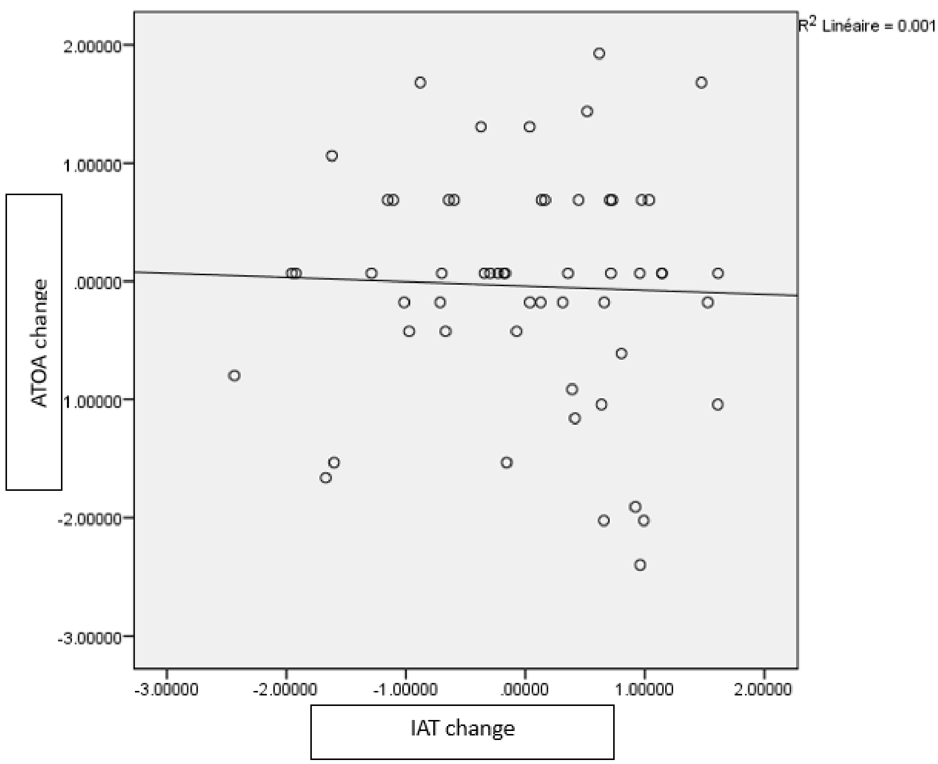


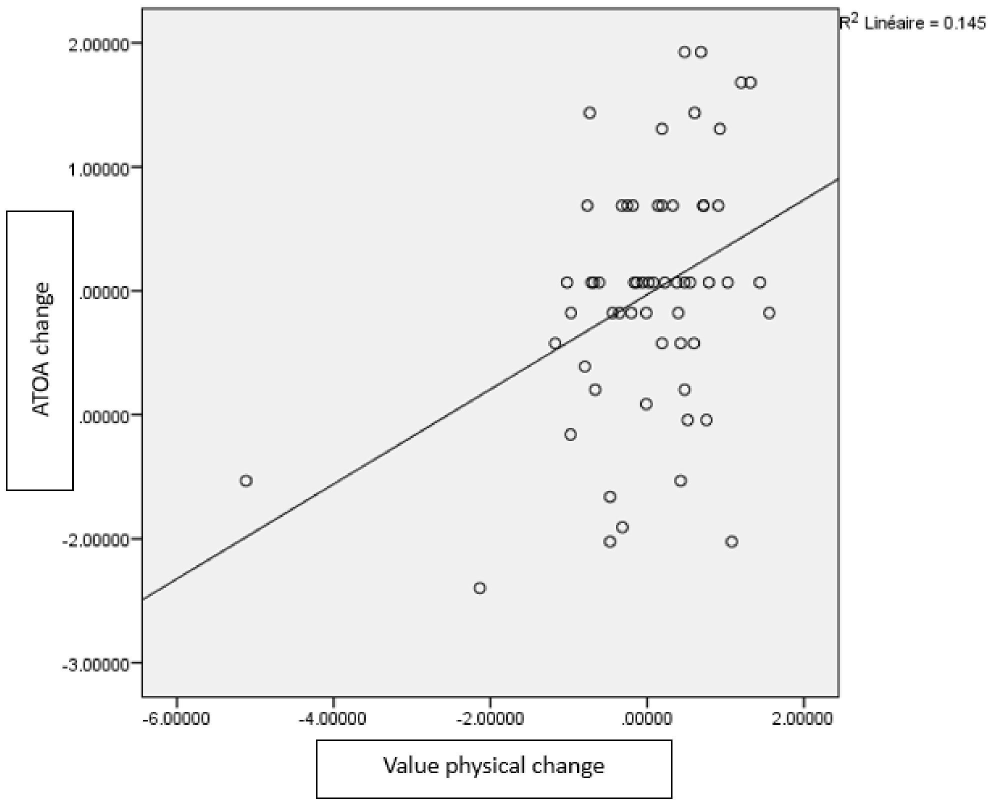


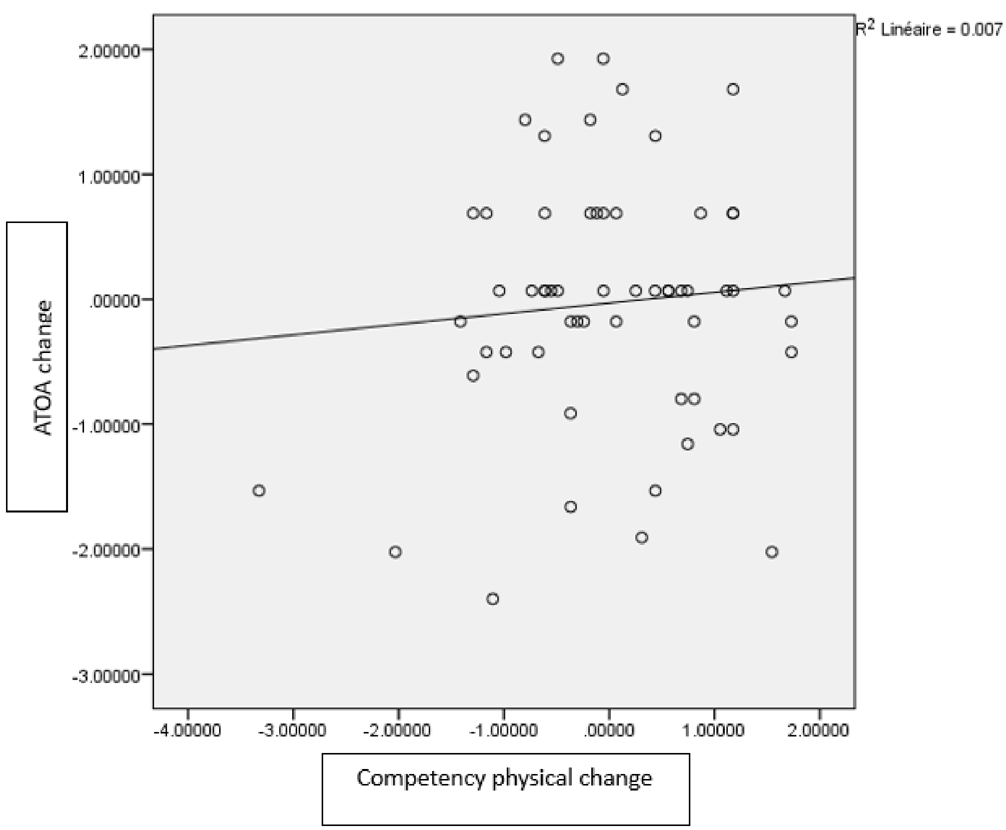

R² Linéaire = 0.007
2.00000
-4.00000
FSA change
-6.00000
-4.00000
-2.00000
.00000
2.00000
Value physical change

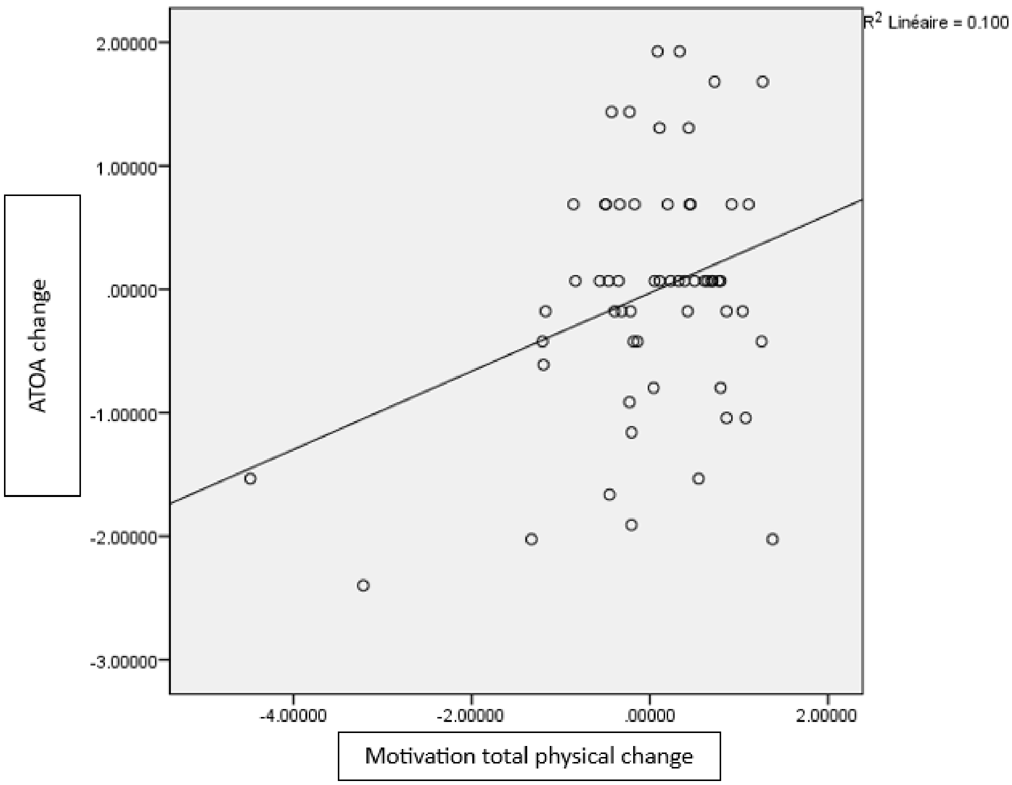

R² Linéaire = 0.006
2.00000
.00000
-2.00000
-4.00000
FSA change
-4.00000
-2.00000
.00000
2.00000
Motivation total physical change

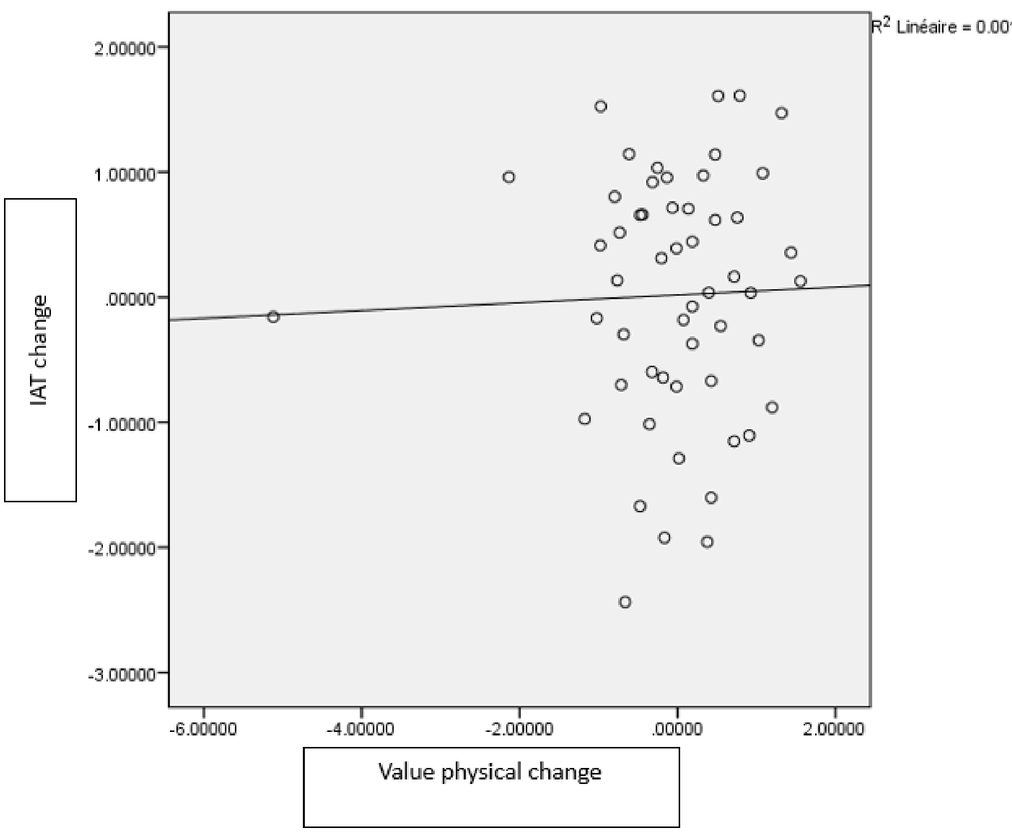

R2 Linéaire = 0.001
2.00000
.00000
-2.00000
-4.00000
FSA change
-4.00000
-3.00000
-2.00000
-1.00000
.00000
1.00000
2.00000
Competency physical change

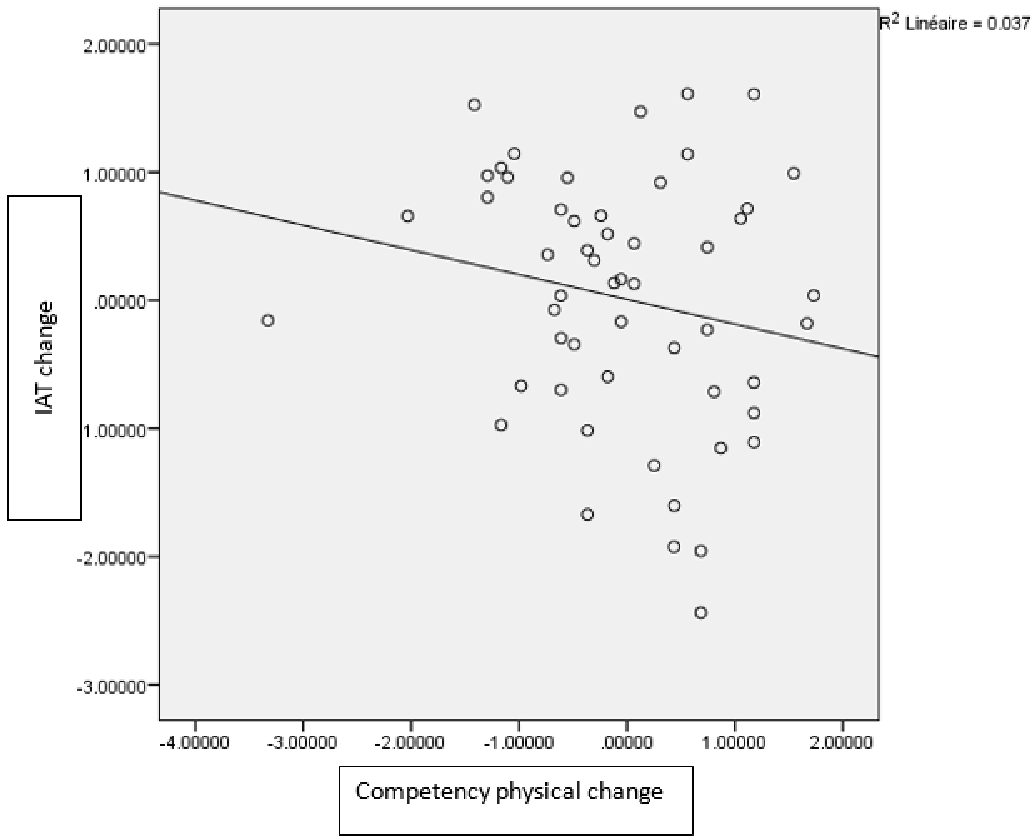

R2 Linéaire = 0.001
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
ATOA change
-3.00000
-2.00000
-1.00000
.00000
1.00000
2.00000
IAT change

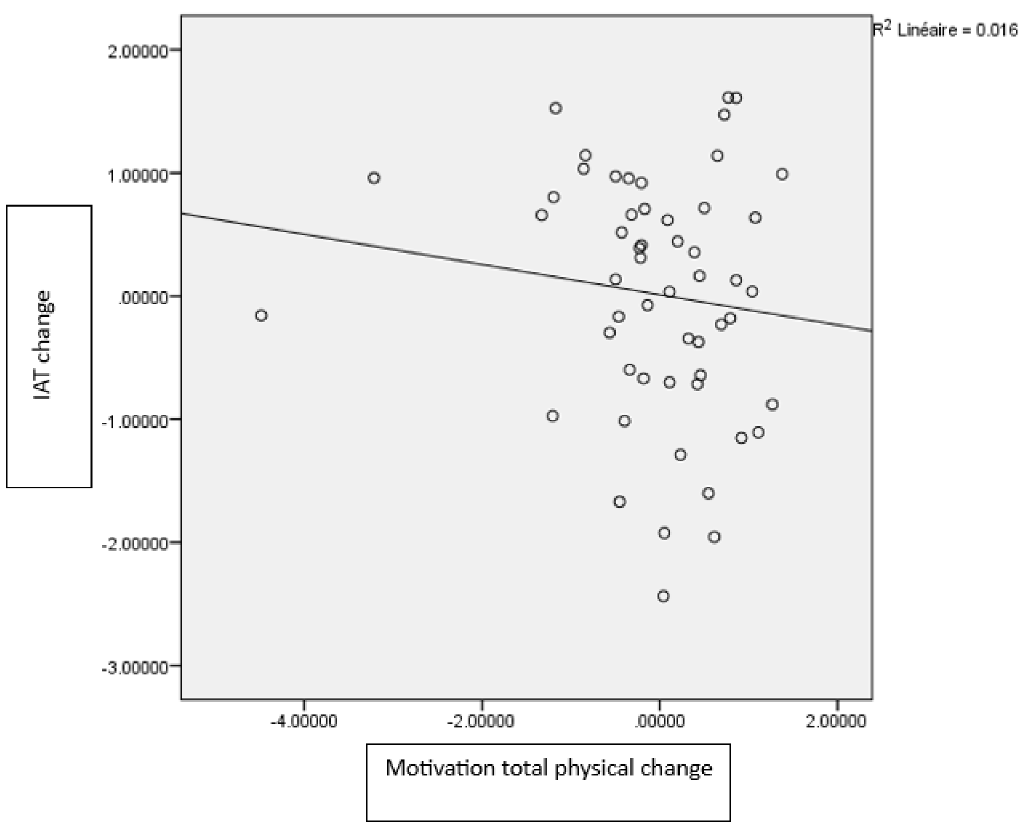

R^2 Linéaire = 0.145
2.00000
1.00000
.00000
.00000
-2.00000
-3.00000
ATOA change
-6.00000
-4.00000
-2.00000
.00000
2.00000
Value physical change

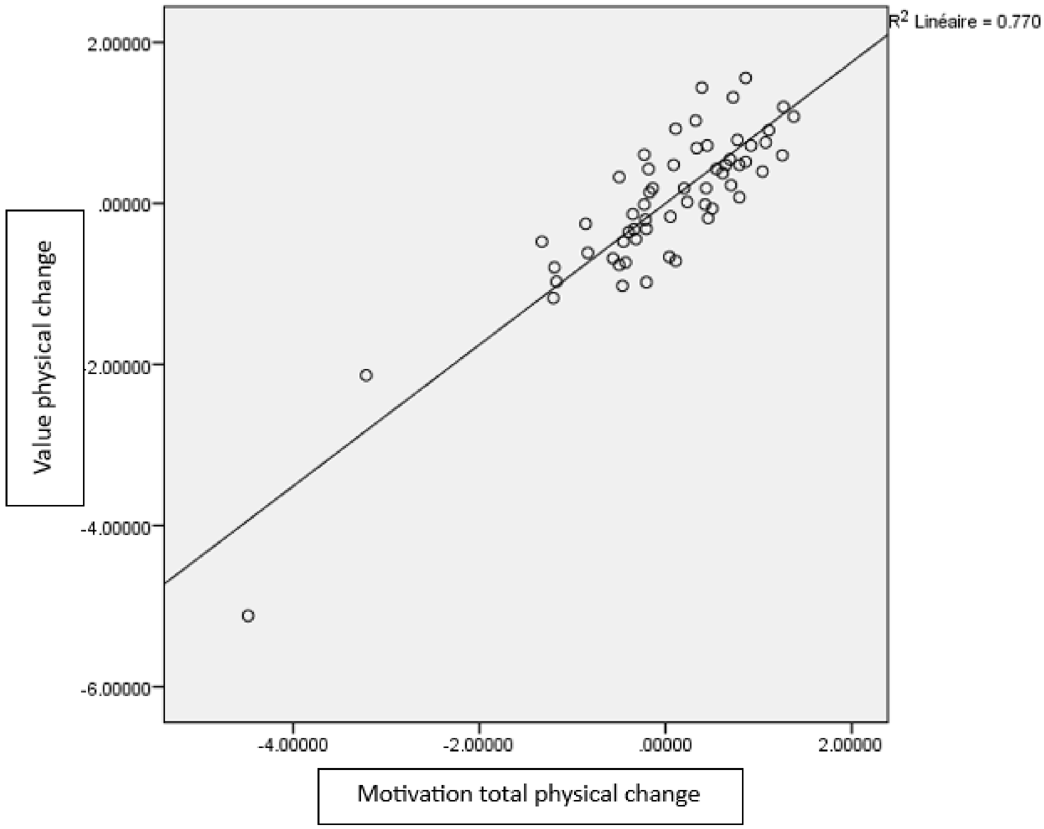

R^2 Linéaire = 0.007
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
ATOA change
-4.00000
-3.00000
-2.00000
-1.00000
.00000
1.00000
2.00000
Competency physical change

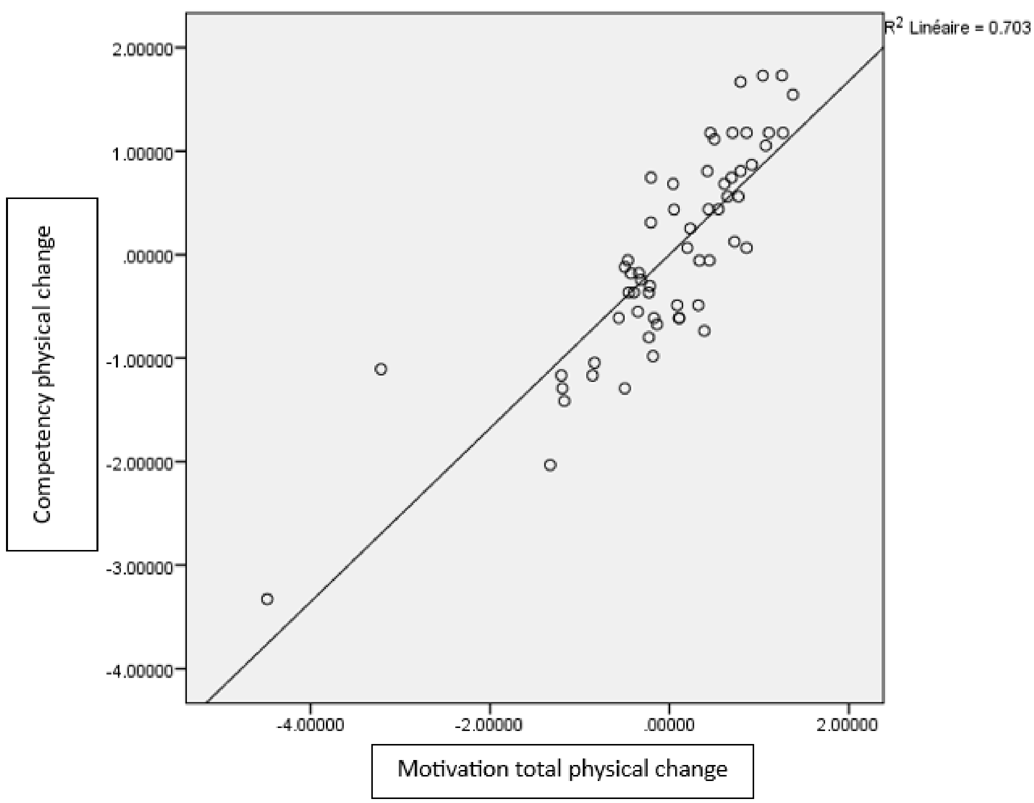

R2 Linéaire = 0.100
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
ATOA change
-4.00000
-2.00000
.00000
2.00000
Motivation total physical change


R2 Linéaire = 0.001
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
IAT change
-6.00000
-4.00000
-2.00000
.00000
2.00000
Value physical change


R2 Linéaire = 0.037
2.00000
1.00000
.00000
1.00000
-2.00000
-3.00000
IAT change
-4.00000
-3.00000
-2.00000
-1.00000
.00000
1.00000
2.00000
Competency physical change


R2 Linéaire = 0.016
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
IAT change
-4.00000
-2.00000
.00000
2.00000
Motivation total physical change


R2 Linéaire = 0.770
2.00000
.00000
-2.00000
-4.00000
-6.00000
-4.00000
-2.00000
.00000
2.00000
Value physical change
Motivation total physical change


R2 Linéaire = 0.703
2.00000
1.00000
.00000
-1.00000
-2.00000
-3.00000
-4.00000
-4.00000
-2.00000
.00000
2.00000
Competency physical change
Motivation total physical change

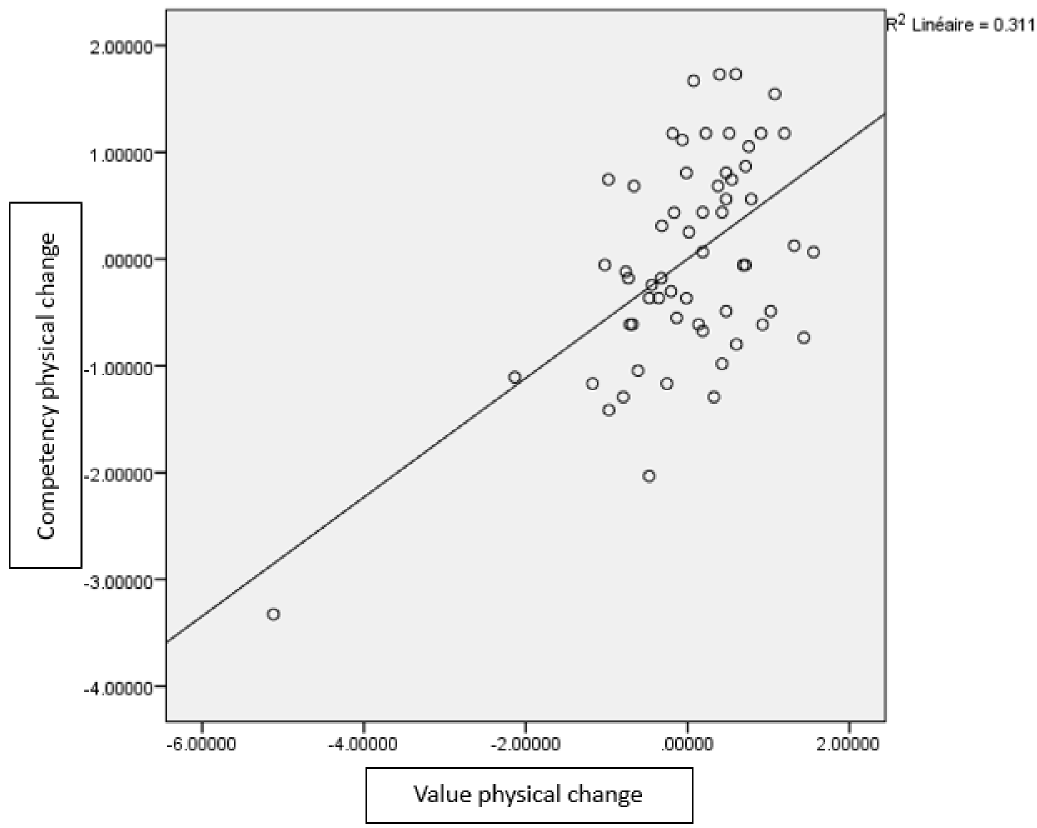
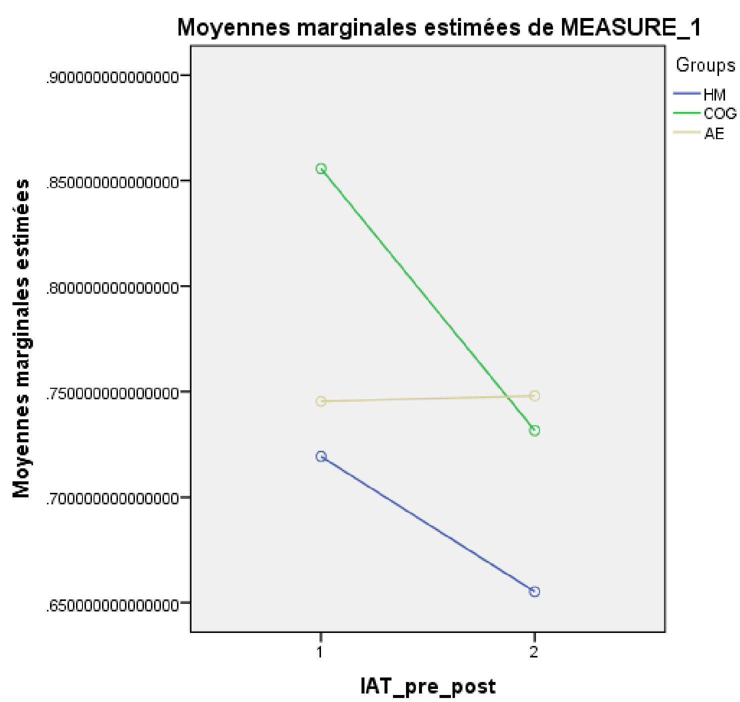
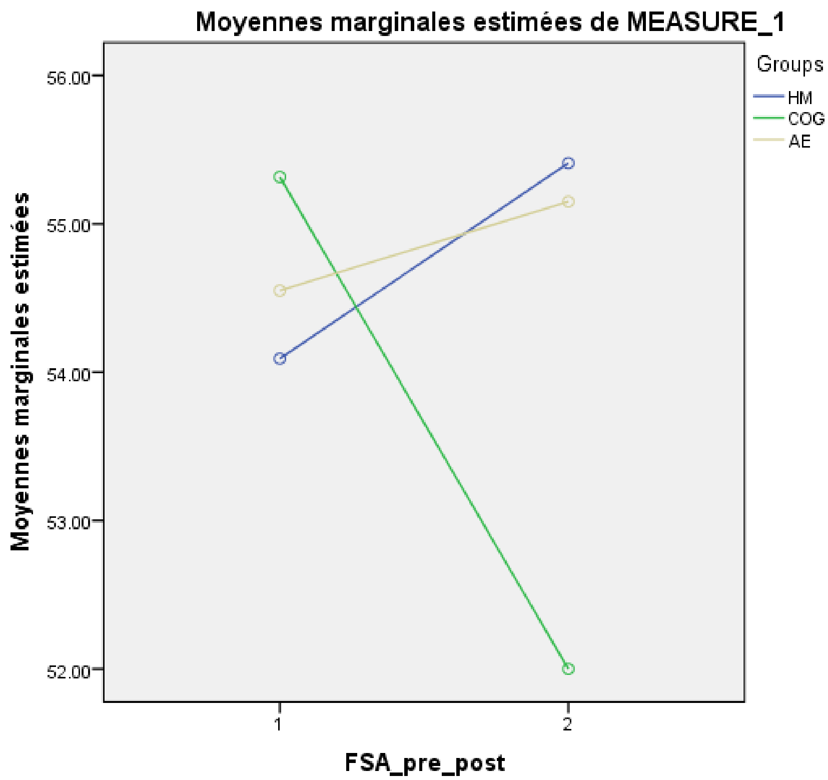
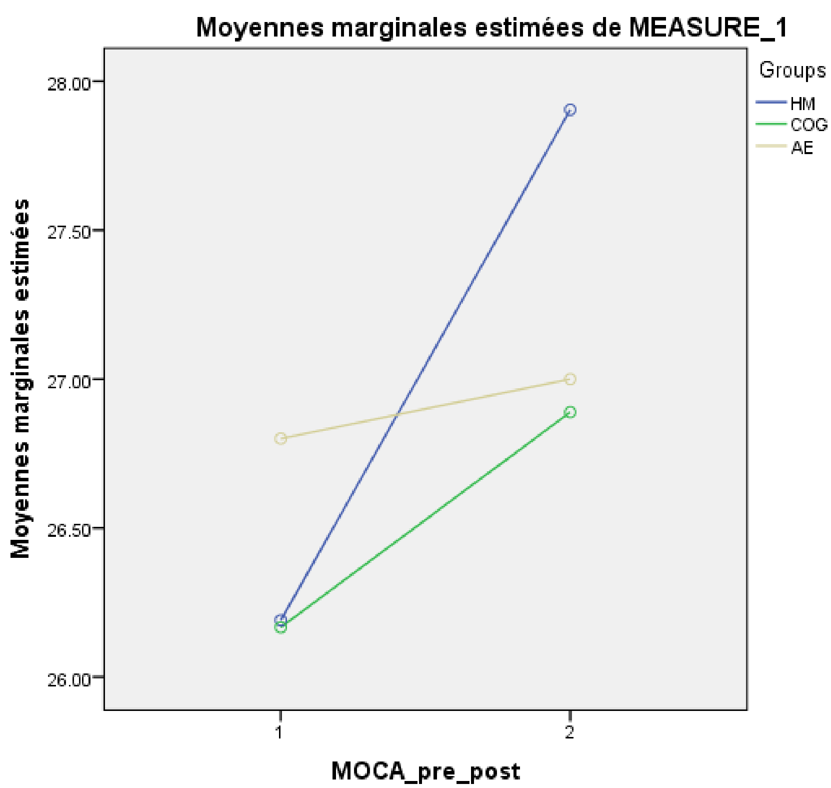
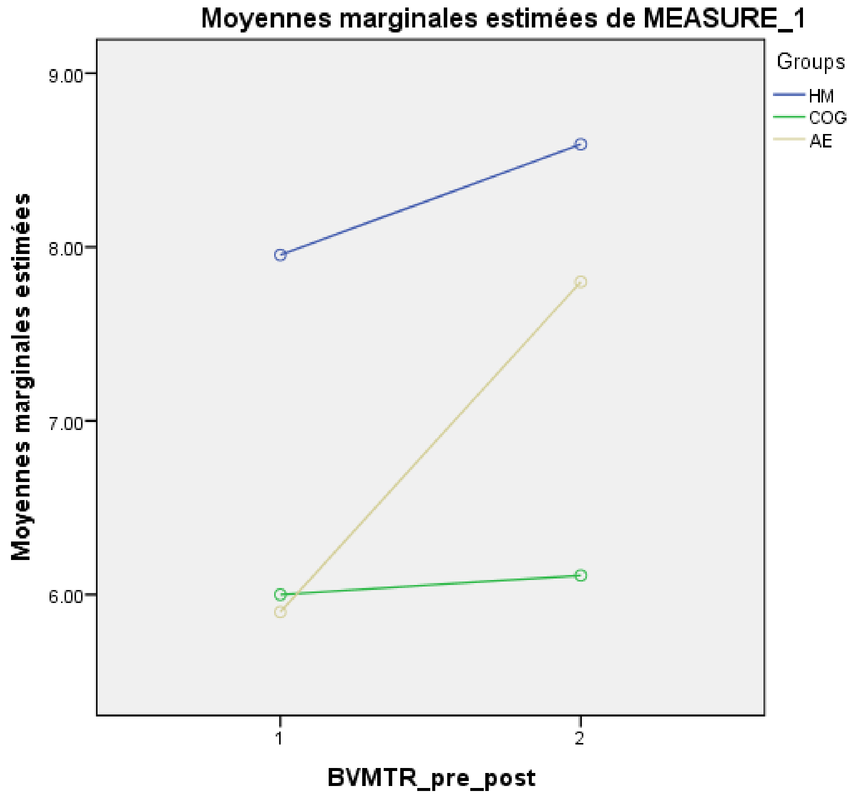


Figure 3. ANOVAs

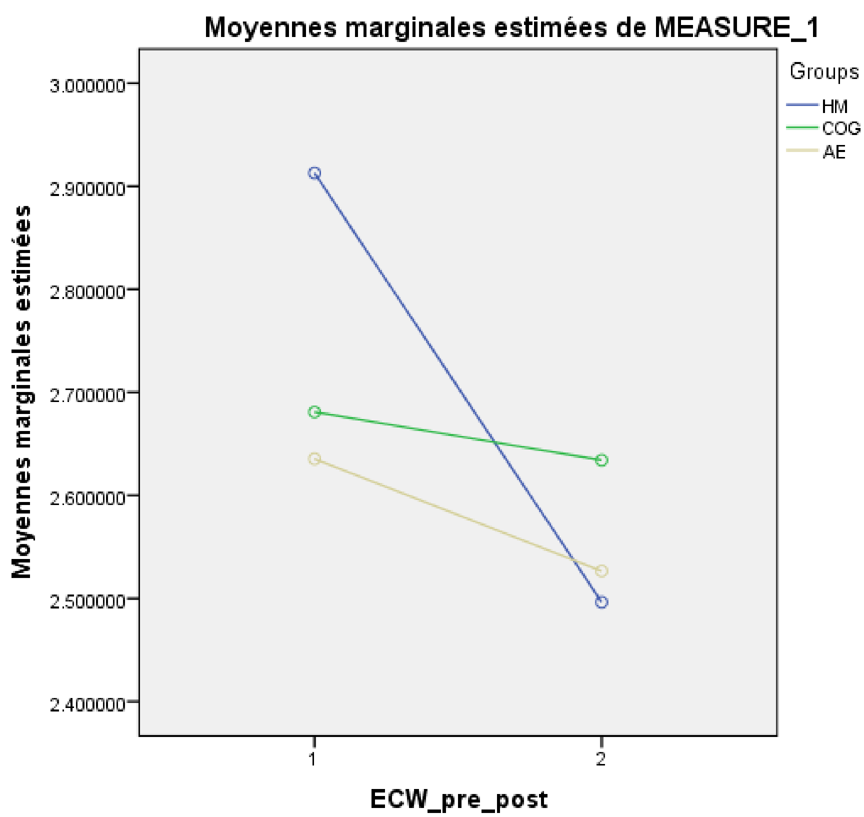



Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
56.00
55.00
54.00
53.00
52.00
Moyennes marginales estimées
1
2
FSA_pre_post

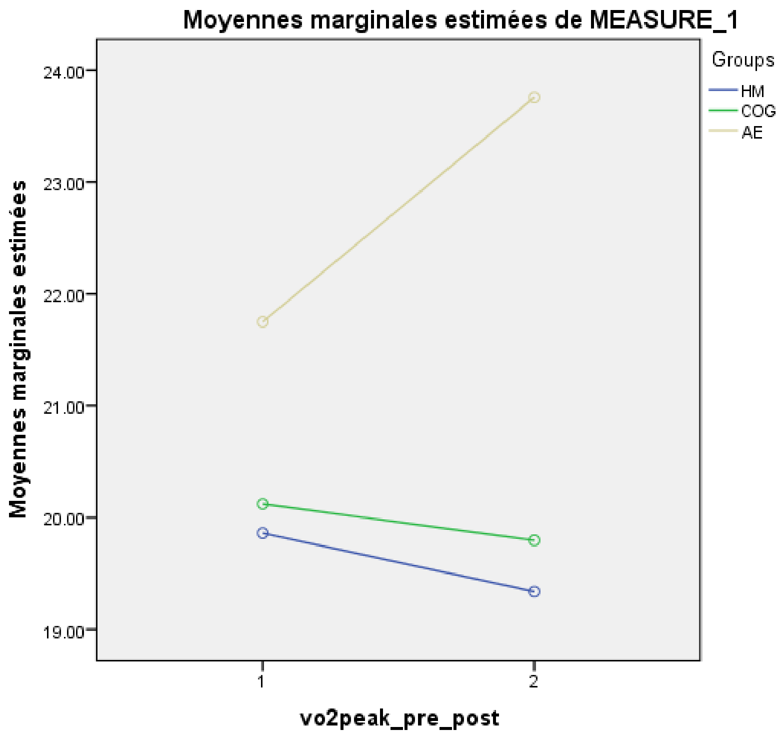

Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
28.00
27.50
27.00
26.50
26.00
Moyennes marginales estimées
1
2
MOCA_pre_post

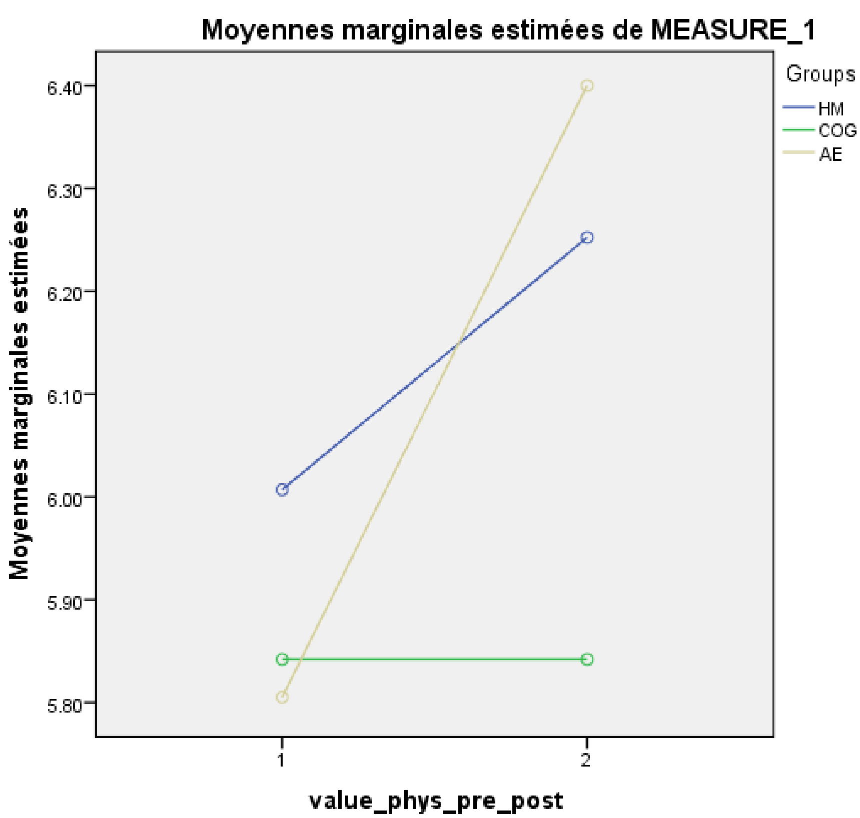


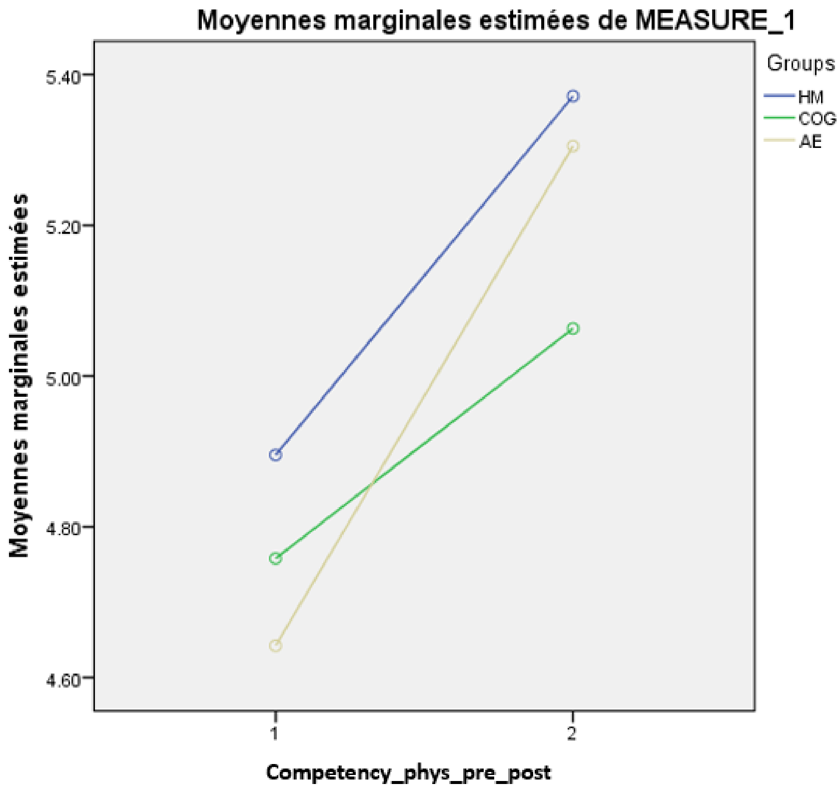
Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
9.00
8.00
7.00
6.00
Moyennes marginales estimées
1
2
BVMTR_pre_post

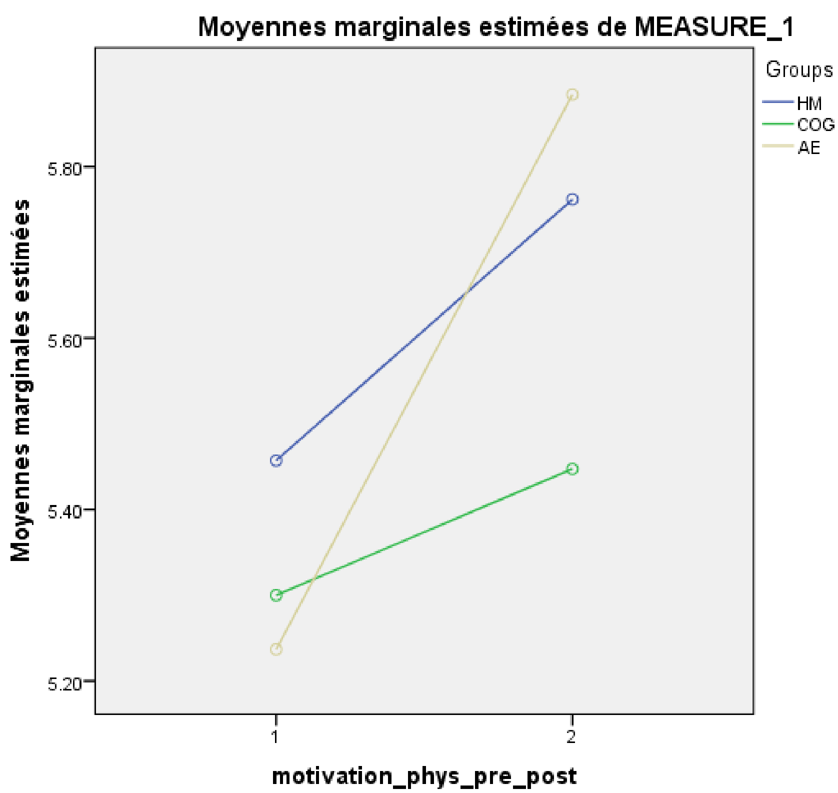


Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
3.000000
2.900000
2.800000
2.700000
2.600000
2.500000
2.400000
Moyennes marginales estimées
1
2
ECW_pre_post


Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
24.00
23.00
22.00
21.00
20.00
19.00
Moyennes marginales estimées
1
2
vo2peak_pre_post


Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
6.40
6.30
6.20
6.10
6.00
5.90
5.80
Moyennes marginales estimées
1
2
value_phys_pre_post


Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
Moyennes marginales estimées
5.40
5.20
5.00
4.80
4.60
1
2
Competency_phys_pre_post


Moyennes marginales estimées de MEASURE_1
Groups
HM
COG
AE
Moyennes marginales estimées
5.80
5.60
5.40
5.20
1
2
motivation_phys_pre_post