FAB workshop UiA
May 28-29, 2024

THE FAB PROJECT | FITNESS AGEING BILINGUALISM

The Research Council of Norway

The aim of this workshop is to disseminate the initial findings of the Fitness, Ageing and Bilingualism project (FAB, NFR 30030) and to hear from experts in relevant fields. The focus of the FAB project was the effect of age on language and cognitive abilities. We investigated two factors that might reduce decline in these abilities in older adults: speaking a second language and regular exercise. Although there is evidence that both help with cognitive functioning, very little research has looked at their effects on language function in healthy ageing. Language function in ageing is especially important for bilinguals who, even when young, can have slower and less fluent speech than monolinguals. We therefore compared cognitive and linguistic functioning in young and older English monolinguals (UK) and Norwegian-English bilinguals (Norway) to determine the effects of being bilingual and ageing. We also ran a physical activity intervention with the older adults in both countries, who took part in a 26-week exercise program after which they were re-tested for language and cognitive function. We measured detailed changes in fitness for all older participants as well as changes in brain structure and function for the older monolinguals. Our aim was to determine the benefits associated with increased fitness for mono- and bilinguals.

Invited speakers

Jubin Abutalebi	Faculty of Psychology, Università Vita - Salute San Raffaele and The Arctic University of Norway
Linda Hildegard Bergersen	Institute of Oral Biology, University of Oslo
Holly Branigan	School of Psychology, University of Edinburgh
Carl-Johan Boraxbekk	Department of Clinical Medicine, University of Copenhagen
Michele Diaz	Department of Psychology, Penn State University
Vincent DeLuca	Department of Language and Culture, UiT, The Arctic University of Norway

FAB Participants

Eunice Fernandes, Allison Wetterlin, Linda Wheeldon	The institue of Foreign languages and translation, University of Agder
Sindre Fosstveit, Hilde Lohne Seiler, Sveinung Berntsen	Department of Sport Science and Physical Education, University of Agder
Katrien Segaert	School of Psychology, University of Birmingham
Jack Feron, Sam Lucas	School of Sport, Exercise & Rehabilitation Sciences, University of Birmingham
Foyzul Rahman	Department of Psychology, Birmingham City University
Yanina Prystauka	Department of Linguistic, Literary and Aesthetic Studies, University of Bergen.

Schedule

Day 1, May 28th

9.00-9.30 Coffee and Welcome

9.30-10.00 **Linda Wheeldon and Katrien Segaert**, FAB project overview

10.00-10.45 **Sindre Fosstveit (FAB)** *HIIT at Home: Enhancing cardiorespiratory fitness in older adults – A randomised controlled trial*

10.45-11.30 **Eunice Fernandes (FAB)**, *Exercise training speeds language comprehension for monolingual but not bilingual older adults: evidence from a randomised controlled trial*

11.30-1.00 Lunch

1.00-2.00 **Holly Branigan (invited speaker),** *It's only words: Referential adaptation across the adult lifespan*

2.00-3.00 **Jubin Abutalebi (invited speaker),** Preventing dementia through bilingualism

3.00-3.30 Coffee

3.30-4.15 **Foyzul Rahman (FAB)** *(1) Explaining age-related word-finding failures using neural and lifestyle measures, and (2) the effect of an exercise intervention and bilingualism on non-linguistic cognitive function.*

4.15-5.00 **Yanina Prystauka (FAB)**, *Exploring language behavior as a function of predicted brain age and physical exercise intervention*

7.00 Conference dinner, Sjøhuset (12A Østre Strandgate)

Day 2, May 29th

9.00-9.30 Coffee

9.30-10.30 **Vincent DeLuca (invited speaker)** *Multilingual experience effects on neurocognitive outcomes throughout the adult lifespan: Insights from the EEG and Cognitive Aging Project (EEG-CAP)*

10.30-11.30 **Michelle Diaz (invited speaker),** *Age-related stability and differences in language production and semantic memory networks*

11.30-1.00 Lunch

1.00-2.00 **Linda Bergersen (invited speaker),** *Mimicking physical exercise with L-lactate injections. A HIIT for neuroprotection and treatment.*

2.00-2.45 **Jack Feron (FAB),** *Cerebral blood flow and arterial transit time responses to home-based exercise training in healthy older adults*

2.45-3.30 Coffee

3.30-4.30 **Carl-Johan Boraxbekk (invited speaker),** *Exercise for brain health – how to make it work?*

Abstracts

Jubin Abutalebi

Preventing Dementia through Bilingualism

Dementia is an umbrella term for a set of neurodegenerative diseases (of which Alzheimer's disease (AD) is the most common one) with debilitating symptoms, primarily impairment of memory and other cognitive abilities, eventually leading to loss of autonomy over everyday activities. It is the leading cause of disability for older adults (World Health Organization, 2017). Increased age is commonly (but not for all types of dementia) a risk factor for development of disease. As the average age of the global population increases, dementia is becoming an increased burden in both societal and financial terms around the world. Dementia was estimated to lead to annual costs of almost a trillion USD in 2016, with predicted annual increase of this amount by 15.94% (Xu et al., 2017). As there is currently no pharmacological cure of dementia, increasingly more interest has been devoted to understanding the factors that can help delay the onset of aging symptoms and promote the longevity of healthy life and cognition. Tackling dementia via preventive or treatment measures has thus been defined as a top societal and scientific goal. In the absence of a pharmacological cure, it is important to identify and study factors that contribute to cognitive resilience in healthy older individuals and people with dementia.

According to the cognitive reserve hypothesis, high-reserve aging seniors experience functional compensation for neural atrophy and, thus, are able to maintain relatively stable cognitive functioning with no or smaller-than-expected impairment. Several lifestyle factors such as regular physical exercise, adequate and balanced nutrition, and educational attainment have been widely reported to contribute to reserve and, thus, lead to more successful trajectories of cognitive aging.

In recent years, it has become clear that bilingualism is also a potential and potent reserve contributor. Yet, there is little communication between the neuroscience of bilingualism research community and researchers working in the field of cognitive aging more generally, despite compelling reasons for it. In fact, bilingualism tends to be overlooked as a contributory factor in the cognitive aging literature, or reduced to a dichotomous trait, despite it being a complex experience. During my presentation I will discuss the benefits of including bilingualism as a protecting factor for cognitive aging.

Linda Hildegard Bergersen (invited speaker)

Mimicking physical exercise with L-lactate injections. A HIIT for neuroprotection and treatment.

Alzheimer's disease (AD) presents a formidable global health dilemma with few effective remedies. In a groundbreaking study, our research delved into the potential of lactate injections, mimicking the impact of physical activity, in combating AD using a transgenic mouse model.

Dividing transgenic mice, and their wild-type counterparts into groups, they administered lactate or vehicle treatments via intraperitoneal and subcutaneous injections four times weekly for 11 weeks. Our aim? Unraveling lactate's effects on AD progression, with

a focus on spatial memory, growth factor expression, anti-inflammatory responses, metabolic gene expression, glutamate signaling, and mitochondrial function. Our findings? Lactate treatment significantly curbed spatial memory decline in transgenic mice, notably boosting spontaneous alternations compared to the vehicle group. Moreover, lactate spurred the upregulation of growth factors and anti-inflammatory genes in wild-type mice. Lactate also orchestrated the upregulation of metabolic genes and rescued glutamate signaling pathways, particularly in female mice with early-onset treatment, potentially influencing synaptic transmission and neuronal function. Intriguingly, lactate treatment elicited sex-specific differential gene expression patterns, underscoring its varied effects on molecular pathways linked to AD pathology. Furthermore, lactate treatment tweaked the expression of mitochondrial proteins, hinting at its role in bolstering mitochondrial function and energy production in neurons. Altogether, these findings hint at lactate injection's potential as a therapeutic game-changer for AD, offering a range of benefits from memory enhancement to neuroprotection, and modulation of key molecular pathways implicated in disease progression.

Carl-Johan Boraxbekk (invited speaker)
Exercise for brain health – how to make it work?

Exercise has been proposed as a promising intervention to reduce the negative effect of aging on brain health, and with the potential to postpone the onset of neurodegenerative diseases. The results, however, are mixed, with large individual differences in effects. In my talk, I will provide an overview about the current status of the underlying neural mechanisms, with a particular focus on studies measuring brain function and structure using MRI but also dopamine neurotransmission using PET. Across my talk individual differences in response will be key, and I will discuss whether a better characterization of individuals before the start of an intervention is the necessary next step to fully harvest the potential of exercise for brain and cognitive health in aging.

Holly Branigan (invited speaker)
It's only words: Referential adaptation across the adult lifespan

Successful communication requires speakers to adapt their language choices appropriately to the communicative context. For example, depending on the situation, the same object might be most appropriately referred to as *an animal, rabbit, bunny, Flopsy,* or *it*. However, speakers' ability to appropriately adapt their choice of words to the communicative context is known to vary consistently among individuals (i.e., from person to person) as well as between groups (e.g., children versus adults) – with important consequences for how successfully and effectively these individuals and groups are able to communicate.

As yet there has been little investigation of whether the ability to adapt word choices appropriately might change with age, and whether any such changes might potentially contribute to some of older adults' communicative difficulties. In this talk I will explore two particularly frequent forms of referential adaptation, lexical entrainment (the tendency to repeat a conversational partner's word choices) and maintenance (the tendency to repeat

recently used words), and how they might change across the adult lifespan. I will present the results of recent studies showing consistent age-related differences in both behaviours, and consider the cognitive mechanisms that might underlie these effects, and the potential implications of these differences for effective communication across the lifespan.

Michele T. Diaz (invited speaker)
Age-related stability and differences in language production and semantic memory networks

Although age is often associated with cognitive change, language abilities show complex patterns of both spared and impaired performance. In this talk, I will discuss two areas of our lab's research: the effect of aging on language production and semantic memory networks. Language production is often associated with age-related differences such as speaking more slowly, having more frequent slips of the tongue, and experiencing more pauses and fillers during speech. While these phenomena are often observed, the underlying mechanism is less clear. To explore these issues, recent work from our lab has examined the neural and behavioral effects of word characteristics such as lexical frequency and neighborhoods (phonological and semantic) in a broad sample of individuals across adulthood. While we observe typical age-related slowing, increases in errors, and increases in functional activation during picture naming, neural and behavioral sensitivity to word characteristics is largely stable across the lifespan. In contrast to language production, semantic memory is generally thought to remain largely stable as we age. Older adults generally have larger and more diverse vocabularies; and demonstrate comparable performance to younger adults when making semantic judgments and during semantic priming tasks. However, the additional information that arises from larger vocabularies and richer experiences incur storage needs. Using a graph theory approach, recent findings from our lab have demonstrated that older adults' semantic memory networks differ from younger adults. We find that older adults' semantic networks are less flexible and break down faster than younger adults. Collectively, these findings suggest that while older adults' sensitivity to phonological and semantic characteristics is stable across the lifespan, the underlying representation and access to that information may decline with age.

Eunice Fernandes (FAB)
Exercise training speeds language comprehension for monolingual but not bilingual older adults: evidence from a randomised controlled trial.

Physical exercise has been claimed to counteract ageing-related cognitive function decline through physiological adaptations associated with cardiorespiratory fitness (CRF hypothesis; Voss & Jain, 2022). However, little is known about potential similar effects on language function. In a cross-sectional study, Segaert et al. (2018) showed that the probability of healthy older adults experiencing tip-of-the-tongue states decreased as a function of increased CRF. We hypothesized that such beneficial effects of CRF to language processing in older adults might extend to language comprehension, and be more evident in bilingual (than monolingual) speakers, for whom language processing is more demanding.

We conducted an exercise intervention in which healthy older English monolinguals (N=80, Age M=65.41) and Norwegian-English bilinguals (N=80, Age M=66.71) were randomly assigned to either an exercise group, that completed a 6-months exercise intervention, or to a control group that maintained their levels of activity throughout the intervention period. Participants' CRF ($VO2_{peak}$) and language function (reaction times (RT) in a spoken word monitoring task) were assessed at pre- and post-intervention.

With mediation analysis, we measured effects at a group level (exercise vs. control, pre- vs. post-testing), but also examined the possible mediation by a prototypical measure of CRF, $VO2_{peak}$. We found an effect of the intervention in cardiorespiratory fitness, whereby participants in the exercise group, compared to the control group, exhibited higher $VO2_{peak}$ in post- compared to pre-testing. The intervention also affected monolinguals' performance in language comprehension, with participants in the exercise group (compared to control group) being faster to detect words at post- than pre-testing, and this effect was mediated by increases in $VO2_{peak}$. This result is consistent with the CRF hypothesis and extends previous evidence for a positive effect of fitness on language function.

However, the intervention did not have an effect on bilinguals' performance in language comprehension, with participants showing instead slowed latencies in word monitoring in post- compared to pre-testing, across the exercise and control groups. There was also no evidence of any mediation effects of $VO2_{peak}$ in the bilingual group. Contrary to our hypothesis (and broader prediction of the CRF hypothesis), the intervention, and its associated increased fitness ($VO2_{peak}$), did not affect bilingual's performance in comprehension. Whereas we have not an explanation for the decreased performance of bilinguals from pre- to post-testing, we show in further exploratory analyses that such detrimental effect is restricted to participants with low L2 proficiency.

Jack Feron (FAB)

Cerebral blood flow and arterial transit time responses to home-based exercise training in healthy older adults

Maintaining brain health and thus cognitive function as we age is important for independent living. Brain vascular health worsens with age, evident by cerebral blood flow (CBF) reductions and lengthening arterial transit time (ATT). Low CBF has been associated with cognitive decline in older adults, yet the effects of exercise training on cerebral haemodynamics remain poorly understood. To investigate training-induced cerebral haemodynamic responses and their associations with cognitive function, 65 healthy older adults (control; n=33, exercise; n=32, aged 60–81 years) completed a 26-week home-based exercise intervention. Cardiorespiratory fitness, CBF, ATT, and cognitive function were measured pre- and post-intervention. Multi-delay pseudo-continuous arterial spin labelling was used to accurately estimate CBF and ATT. Results showed no between-group differences in CBF or ATT following the intervention. However, exercise participants with the greatest cardiorespiratory fitness gains (n=17) experienced global CBF reductions (-4.0 [-7.3, -0.8] mL/100 g/min). Furthermore, in the whole exercise group, there was an association between changes in cardiorespiratory fitness and global CBF (**β**=-0.43 [-0.81, -0.04), whereby cardiorespiratory fitness gains were associated with CBF declines. Cognitive function changed in neither group, nor were cognitive function changes associated with changes in CBF or ATT. These data

indicate that exercise training in older adults may induce global CBF reductions, which are associated with the magnitude of cardiorespiratory fitness gains experienced. However, these changes do not appear to affect cognitive function. Future research is warranted to assess training-induced changes in cerebral oxygen extraction and the cerebral haemodynamic responses to long-term exercise training or different types of interventions (e.g., weight-loss).

Sindre Fosstveit (FAB)

HIIT at Home: Enhancing Cardiorespiratory Fitness in Older Adults – A Randomised Controlled Trial

This study aimed to investigate the effectiveness of a six-month home-based high-intensity interval training (HIIT) intervention to improve peak oxygen consumption ($\dot{V}O_2$peak) and lactate threshold (LT) in older adults. 233 healthy older adults (60-84 years; 54% females) were randomly assigned to either six-month, thrice-weekly home-based HIIT (once-weekly circuit training and twice-weekly interval training) or a passive control group. Exercise sessions were monitored using a Polar watch and a logbook for objective and subjective data, respectively, and guided by a personal coach. The outcomes were assessed using a modified Balke protocol combining $\dot{V}O_2$peak and LT measures. General linear regression models assessed between-group differences in change and within-group changes for each outcome.

There was a significant between-group difference in the pre-to-post change in $\dot{V}O_2$peak (difference: 1.8 [1.2;2.3] mL/kg/min; exercise: +1.4 [1.0;1.7] mL/kg/min (~5%); control: -0.4 [-0.8;-0.0] mL/kg/min (~-1.5%); effect size (ES):0.35). Compared to controls, the exercise group had lower blood lactate concentration (-0.7 [-0.9;-0.4] mmol/L, ES:0.61), % of peak heart rate (-4.4 [-5.7;-3.0], ES:0.64), and % of $\dot{V}O_2$peak (-4.5 [-6.1;-2.9], ES:0.60) at the intensity corresponding to pre-intervention LT, and achieved a higher treadmill stage (% incline) at LT (0.6 [0.3;0.8]; ES:0.47), following the intervention.

This study highlights the effectiveness of a home-based HIIT intervention as an accessible and equipment-minimal strategy to induce clinically meaningful improvements in cardiorespiratory fitness in older adults. Over six months, the exercise group showed larger improvements in all outcomes compared to the control group. Notably, the LT outcome exhibited a more pronounced magnitude of change than $\dot{V}O_2$peak.

Vincent DeLuca (Invited speaker)

Multilingual experience effects on neurocognitive outcomes throughout the adult lifespan: Insights from the EEG and Cognitive Aging Project (EEG-CAP)

Multilingualism has been demonstrated to lead to a more favorable trajectory of neurocognitive aging, yet our understanding of its effects on neurocognition across the lifespan remains limited. Moreover, other lifestyle factors (e.g., exercise, education) have also been found to affect the trajectory of cognitive aging (CA), but multilingual effects on CA have rarely been examined while taking these into account. Herein we present an overview of our ongoing project, the EEG and Cognitive Aging Project (EEG-CAP) inclusive of some data from subsets of the project. EEG-CAP assesses the extent to which multilingual experience affects various neural and cognitive outcomes across the adult lifespan while

accounting for other known contributory lifestyle factors. We collect data on both language background and usage patterns and engagement in various lifestyle factors engagement from a sample of multilingual individuals with a wide age range. Subjects also undergo a battery of cognitive tasks tapping into aspects of attentional control and memory, while EEG is recorded; resting state EEG (rs-EEG) is also recorded.

We first discuss results from an analysis on the rs-EEG data which indicate that degree of multilingual engagement moderates the age-related decline in whole-brain resting state power across alpha and theta bands, and an interaction between age and MLD on resting state coherence across alpha, theta, and low beta frequency bands. Time permitting, we will also discuss some preliminary results examining the extent to which multilingual experience affects attentional control and episodic memory outcomes across the adult lifespan. These data provide evidence of bilingual engagement as a factor that modulates age-related decline across several aspects of neurocognition and reinforces the interpretation of bilingualism as an independent modulatory factor in neurocognitive aging.

Yanina Prystauka (FAB)

Exploring language behavior as a function of predicted brain age and physical exercise intervention

In this presentation, I will explore two questions: firstly, does predicted brain age (Cole et al., 2018) correlate with language task performance in a sample of older adults? Secondly, can a targeted cardiovascular fitness intervention offset age-related decline in word production within the same cohort?

Regarding the first question, while chronological aging is universal, this doesn't hold true biologically: some individuals undergo accelerated or delayed age-related biological degeneration (Elliott et al., 2021). Using machine learning and large samples of MRI data (Cole & Franke, 2017), we can estimate an individual's brain age. Comparing predicted brain age to chronological age allows us to investigate its impact on linguistic behavior. For our dataset, we computed a BrainGAP measure as (predicted brain age - age)/age and explored its relationship with participants' performance on a battery of language comprehension and production tasks.

Turning to the second question, with healthy aging there is a well-documented decline in cognitive abilities, including difficulties in word finding. A phenomenon known as "tip-of-the-tongue" becomes more prevalent, where individuals struggle to retrieve a known word. Cross-sectional studies (Segaert et al., 2018) suggest that higher aerobic fitness levels correlate with a lower occurrence of tip-of-the-tongue states in older adults, even after accounting for age and vocabulary size differences. These states have been linked to structural integrity of the insula region (Shafto et al., 2007; 2010) and functional activation in an extended network of language-related areas (Diaz et al., 2014). Here, we evaluated our sample of older participants in a tip-of-the-tongue (definition) task-fMRI session pre- and post-intervention (i.e., a controlled six-month home-based exercise intervention which increased fitness only in the exercise group). Whole brain analyses revealed regions for tip-of-the-tongue vs know response including precuneus, angular, cingulate, and superior frontal gyri. While no significant whole-brain effects of the intervention were observed, ongoing analyses concentrate on connectivity changes, which may be more sensitive to lifestyle

modifications with age (Tsvetanov et al., 2018). Overall, this research contributes to understanding the nuanced relationship between physical exercise, language abilities, and the underlying neural mechanisms in aging individuals.

Foyzul Rahman (FAB),

(1) Explaining age-related word-finding failures using neural and lifestyle measures, and (2) the effect of an exercise intervention and bilingualism on non-linguistic cognitive function.

Abstract: In this two-part talk, I will first cover some recent work which brought together brain function, structure, perfusion, and cardiorespiratory fitness to investigate word-finding failures. Using commonality analysis on 73 neurologically healthy older adults, we found that functional activation of language networks associated with tip-of-the-tongue states is in part determined by age and, interestingly, cardiorespiratory fitness. Age-associated atrophy and perfusion in regions other than those showing functional differences also accounted for variance in tip-of-the-tongue states. Thereafter, I will talk about some ongoing analyses with intervention data from the FAB study that seeks to delineate changes in cognitive function following a 6-month home-based exercise intervention (control vs. exercise) and according to language status (mono vs bilingualism). I will talk about how exercise and language status interact to shed new light on the bilingual advantage hypothesis.