Data analyses on the use of mental lexicon translation adapted neuropsychological tools in Greek MCI older adults

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Abstract
The present 15-month research (funded by the Partnership Agreement for the Development Framework 2014-2020, Project title: Translation Prototypes for the Appropriation of Foreign Language Cognitive Disorder Screening Tests and Cross-Scientific Networks of Neuropsychological Intervention; Project code: MIS 5005306) focuses on the observation of mother tongue verbal memory activation in Greek older adults diagnosed with Mild Cognitive Impairment (MCI). We performed multiple translation adaptations of the Swedish Lexical Decision Test (SLDT) under various non-pharmacological interventions designed for this MCI population. Our work was initiated from the SLDT-based Greek translated test (Dr Neofytidou's PhD research; 2018). We opted for the multiple translations of the Greek version of the SLDT in order to avoid possible repetition effects caused by the repeated administration of the same test to the same individuals (insight gained from Ms Tigka's PhD process within the framework of our research project). A total of 72 Greek MCI older adults (aged 55-85) participated in four experimental groups: English as a Foreign Language (EFL) learning, basic Information Technology (IT) skills learning, physical activity, and sleep hygiene. The research was conducted at the day care units for patients with dementia of the Greek Association of Alzheimer's Disease and Related Disorders, in Thessaloniki, Greece. Several quantitative analyses were used to evaluate and analyse the participants' performance on the SLDT translation adaptations, i.e. descriptive statistics, correspondence analysis, and multiple correspondence analysis. It was shown that EFL and IT learning had a positive impact on the general mental lexicon. Additionally, age and educational level shaped the participants performance both on the general and the specialised lexicon.

Keywords: translation, adaptation, localization, lexicon, language, memory

JEL Classifications: C12, C18, C93, I12, I31

Introduction

The steadily increasing rate of ageing of the global population entails a proportionate increase of people with dementia, hence the worldwide focus of scientific research on senior diseases. Of particular interest is the study of the pre-morbid phase of dementia, namely Mild Cognitive Impairment (MCI), a condition of subtle cognitive decline, whereby memory or other cognitive dysfunctions are expected to arouse.

Research has revealed that a predicting factor of early brain dysfunction may be the evaluation of the mental lexicon. The term mental lexicon entails the visualised location in the brain of lexical unit representations for words known to the reader. The traits stored in the mental lexicon for each learnt word concern pronunciation, spelling, syllable number, grammatical features, along with syntactic, semantic, and pragmatic information (Coltheart, 2004; Kehayia, 2002, pp. 139-172). The mental lexicon is usually assessed with printed lexical decision tests comprising sight words and nonwords. These tests are simple, short, not timed, and not cognitively demanding. Such an example is the Swedish Lexical Decision Test (SLDT) (Alkmvist et al., 2007), which assesses pre-morbidity through the visual perception of single word units.

The original research presented in this paper constitutes partial fulfilment of a 15-month study funded by the Partnership Agreement for the Development Framework 2014-2020 (Project title: Translation Prototypes for the Appropriation of Foreign Language Cognitive Disorder Screening Tests and Cross-Scientific Networks of Neuropsychological Intervention; Project code: MIS 5005306). Our main task was to evaluate the activation of mother tongue verbal memory under different non-pharmacological interventions, which focused either on cognition or on physical activity and which were designed for Greek MCI older adults. Four intervention types were chosen, namely English as a Foreign Language (EFL) learning, basic Information Technology (IT) skills learning, physical activity, and sleep hygiene.

To meet the requirements of our study, the SLDT was translated and adapted for the creation of a Greek lexical decision test, henceforth General Lexicon Test (GLT), tailored to meet the requirements of Greek pre-morbid seniors. Apart from the GLT, the SLDT was accordingly adapted and re-constructed with specialised lexical items each intervention featured. More specifically, it was adapted to English four times, to depict increasing degrees of linguistic competence, while it was further adapted to include vocabulary related with basic IT skills, physical activity, and sleep hygiene, respectively.

Our end-products, i.e. the localized versions of the SLDT, underwent a number of changes with respect to the social and medical context of action, in which the translation process had to be taken as a starting point for our analysis. Our adaptations were based on Pierre Bourdieu’s social theory of action, i.e. the concept of habitus. Bourdieu’s work is founded on the premise that any agent of cultural production, in our case our MCI older adults, occupies a particular position within a social space. The relative position of our participants in the space of production shapes the form and the context of what is being produced. Furthermore, the field of production influences our agents, i.e. our MCI older adults, by

providing them with the knowledge and practices for their integration in the social relations in the specific field. According to Bourdieu, in this sense, fields are like markets, in which the agents complete and profit with the aim of controlling the field and its resources, in our case, our interventions (Kaindl, 1999). According to the descriptors of the SLDT, each research group was expected to adapt the original test to the given circumstances in order to produce new localized versions.

EFL learning

The engagement of MCI patients in a systematic second language learning process might enhance their cognitive ageing (Antoniou & Wright, 2017). The targeted training of the brain in the acquisition of new knowledge reinforces and alters neural activity while improving neuroplasticity (Koizumi, 2004). Despite the age factor, the brain retains its ability to mould by responding to experiential and environmental stimuli (Greenwood & Parasuraman, 2010), such as teaching and learning (Goswami, 2014). Nonetheless, it should be clinically proved which combination of such activities and in what time leads to more normal ageing (Stern, 2012). A vast body of research has focused on the potential cognitive benefits of bilingualism against dementia (Calvo et al. 2016). However, foreign language (FL) learning is a more controllable situation than bilingualism: within the FL setting, the quantitative and qualitative exposure of the learners to the FL, the course design and material, along with the frequency and duration of lessons are greatly conditioned by the teacher. The effects of FL on the prevention of dementia are still insufficiently researched.

Basic IT skills learning

As regards the positive effects of IT on MCI, older adult attention, word naming memory, verbal comprehension, writing skills, social skills, mood, and emotional management have improved, following computer training (De Luca et al., 2014). The affordances of technology may also be used for the detection of mild functional changes (e.g. attention, working memory, episodic memory, executive function), which may signal incidence of MCI in older adults, especially for those living on their own (Kaye et al., 2016).

Physical activity

Physical exercise and mental work are positively correlated and affect cognitive functioning and reaction time in older adults. Research has shown that increased levels of physical activity reduce the risk of cognitive decline (Laurin et al., 2001). Additionally, physical exercise, as a component of a multifactorial intervention, has effectively reduced the risk and rate of decline among community-dwelling older adults (Sherrington et al., 2016). A further study has corroborated these findings, giving additional support to the correspondence of physical exercise with dementia syndromes and cognitive decline (Müller et al., 2017).

Sleep hygiene

Sleep disorders are a common condition in MCI and Alzheimer's disease (AD) patients (van der Linde et al., 2010). MCI patients who report daily drowsiness at first examination are twice as likely to progress to dementia over the next three years compared to those without somnolence (Foley et al., 2001). The circadian rhythms and sleep in

MCI patients differ significantly compared to healthy people, in a way similar to the changes noticed in AD (McKinnon et al., 2014). If sleep disorders were identified in the precursor stage of dementia, appropriate therapies could be directly recommended and delay the worsening of the clinical picture and patient function (Guarnieri et al., 2015). Nonetheless, the underlying mechanisms implicated in the effect of sleep on cognitive functions have not been fully clarified, even though specific brain areas appear to be particularly sensitive to the lack of sleep (Durmer & Dinges, 2005). However, there is evidence that sleep improvement interventions can boost verbal memory (Valencia-Flores et al., 1996).

Materials and Methods

Participants

The experimental participants were recruited from a cohort of volunteers who accepted to participate in one of the aforementioned intervention programmes. All participants were community-dwelling, already diagnosed with MCI, and had no record of auditory or visual impairment. They all attended cognitive stimulation programmes at the day care units for patients with dementia of the Greek Association of Alzheimer's Disease and Related Disorders (GAADRD), in Thessaloniki, Greece. Baseline cognitive level was determined with the administration of a battery of neuropsychological examinations (MMSE, MoCA, FRSSD, FUCAS, and GDS) by the psychologists and neurologists of the GAADRD. The small sample number was due to the limitations of the specific study descriptors; we were requested to confine our research to a certain number of individuals and analyse these limited data with the purpose of expanding and replicating them in a future study. All seniors signed consent forms to participate in the research sub-study of their choice.

EFL learning

Participants: The experimental group comprised 11 MCI Greek senior educated participants (6 male, 54.5%; 5 female, 45.5%; mean age: 70, SD±5.64; mean years of education: 12, SD±2.57). The participants either had no prior knowledge of English or had taken some lessons four or more decades before this research. Their EFL competence ranged between the A0 and A1 levels, according to the Common European Framework of Reference for Languages (CEFR, 2001, pp. 22-29). Their performance was compared to a control group comprised by 11 Greek female retired EFL teachers (mean age: 66, SD±6.38; mean years of education: 16.55, SD±0.82).
Course Design: The MCI seniors were divided into two groups and were taught EFL for 6 months (October 2018 – March 2019). Every week the participants attended a consecutive two-hour class (total: 44 hours) delivered in the classroom by the first author, who also designed the curriculum. The level of English conformed to the A Level of language competence, i.e. basic knowledge (according to the CEFR).
Evaluation: The experimental group was evaluated three times; at the beginning of the course, three months after the lessons had started, and at the end of the course. Each time, the assessment tools were two: the GLT and a re-translated English version of the test, adapted to the participants' level of English competence. The triple evaluation was decided because FL learning is directly related to the development of the mental lexicon. The English course was the only intervention involving systematic natural language teaching and learning, hence the need for more frequent reassessment (3 time points) and stricter statistical analysis. Additionally, because

language learning is a dynamic process, the level of English slightly increased along the course of time, providing an additional staging factor to the intervention. The control group was evaluated on the GLT and a re-translated English version adapted to the B Level of competence (according to the CEFR).

Basic IT skills learning & Physical activity

Participants: The IT training experimental group comprised 20 MCI Greek senior educated participants (4 male, 20%; 16 female, 80%; mean age: 69.75, SD±6.67; mean years of education: 11.35, SD±4.2). The physical exercise experimental group also comprised 20 MCI Greek senior educated participants (3 male, 15%; 17 female, 85%; mean age: 73.5, SD±5.9; mean years of education: 10.9, SD±4.68). Another 20 cognitively healthy older adults were recruited to constitute the control group (3 male, 15%; 17 female, 85%; mean age: 68.1, SD±7.64; mean years of education: 12.75, SD±3.9).
Evaluation: The experimental groups were assessed on the same test as the control group twice; before joining the training and after 3-4 months of training. Additionally, they were evaluated post-intervention on two specialised versions of the GLT, which were formulated with vocabulary employed during the IT and physical training, respectively. The control group was assessed on the GLT once.

Sleep hygiene

Participants: A total of 20 MCI Greek senior educated participants (2 male, 20%; 18 female, 80%; mean age: 71, SD±6.65; mean years of education: 10.9, SD±4.12) diagnosed with sleep disorders were included in the study. They all had their medical history taken, with an emphasis on sleep disorders; they underwent neuropsychological assessment, and were examined on the modified Pittsburgh Sleep Quality Index (mPSQI) and the GLT.
Intervention: After the initial evaluation, they were asked to wear an actigraphy monitoring device for 4 days, in order for the researcher to objectively monitor and analyse their sleeping habits. The participants were then divided into two groups of 10 people each. The active control group was given general instructions on a sleep hygiene programme. The experimental group, additionally to the instructions on the sleep hygiene programme, was asked to walk for 30 minutes, 4 days a week. The intervention lasted for 15 days. Upon the end of the fortnight, all of the participants wore the actigraphy monitoring device for another 4 days, were all re-assessed on the mPSQI, the GLT, and were given a specialised version of the latter test, which was formulated with vocabulary employed during the medical history interviews concerning sleep disorders.

Results

A total of 72 Greek MCI older adults participated in this study; 13 male (18.1%) and 59 female (81.9%). The mean age of the sample was 71.33 years (SD±6.14), while the mean education was 11.42 years (SD±4.2). The distribution of the sample across the intervention groups was as follows: EFL, 16.7%; IT, 27.8%; physical activity, 27.8%; sleep hygiene, 13.9%; sleep hygiene & physical activity, 13.9%. The distribution of males and females across the interventions was notable: in EFL, both genders were equally distributed (8.9%), while for the rest of the interventions females were the majority: IT: 23.6% vs 4.2% (fem vs male); physical activity: 23.6% vs 4.2%

(fem vs male); sleep hygiene: 12.5% vs 1.4% (fem vs male); sleep hygiene & physical activity: 13.9% vs 0% (fem vs male).

For tests with a numerical score, performance standards have to be set. A performance standard is the boundary between two levels on the continuum scale reported by a test that is represented by a "cut-off score". In our study, the cut-off score of 60% or higher was chosen to indicate satisfactory performance on all the lexicon tests, general and specialised ones. Table 1 displays the pre-post intervention satisfactory performance on the GLT across variables (i.e. age group; educational level; intervention type):

Table 1: Pre-post intervention satisfactory GLT performance across variables

Variables	**Pre-intervention**	**Post-intervention**
	60% or higher	
55-64	16.4%	17.9%
65-74	53.7%	52.2%
75+	29.9%	29.9%
up to 9 education years	38.8%	37.3%
9+ education years	61.2%	62.7%
EFL learning	16.4%	16.4%
Basic IT skills learning	29.9%	29.9%
Physical activity	26.9%	26.9%
Sleep hygiene	13.4%	13.4%
Sleep hygiene & physical activity	13.4%	13.4%

Apart from the 60% cut-off score, the participants' performance pre-post intervention was grouped according to whether it improved, it was invariable, or it worsened. On the whole, 47.1% of the participants' performance improved, 32.9% was invariable, and 20.0% worsened post-intervention. Table 2 displays the post-intervention evaluation of the participants' performance across variables (i.e. age group; educational level; intervention type).

According to the analysis (Graph 1), there seems to be a tendency for improvement depending on the intervention type. More specifically, EFL and IT learning appear to have contributed more to the improvement, further development, and perception of the vocabulary used. Also, age seems to have contributed positively to the improvement of the performance on the GLT.

Table 2: Post-intervention evaluation of improvement, invariability, and worsening across variables

Variables	Improved	Invariable	Worsened
55-64	18.2%	21.7%	7.1%
65-74	51.5%	39.1%	71.4%
75+	30.3%	39.1%	21.4%
up to 9 education years	36.4%	47.8%	35.7%
9+ education years	63.6%	52.2%	64.3%
EFL learning	24.2%	4.3%	7.1%
Basic IT skills learning	36.4%	30.4%	7.1%
Physical activity	27.3%	21.7%	42.9%
Sleep hygiene	6.1%	21.7%	21.4%
Sleep hygiene & physical activity	6.1%	21.7%	21.4%

Graph 1: The effect of each intervention type on the participants' performance

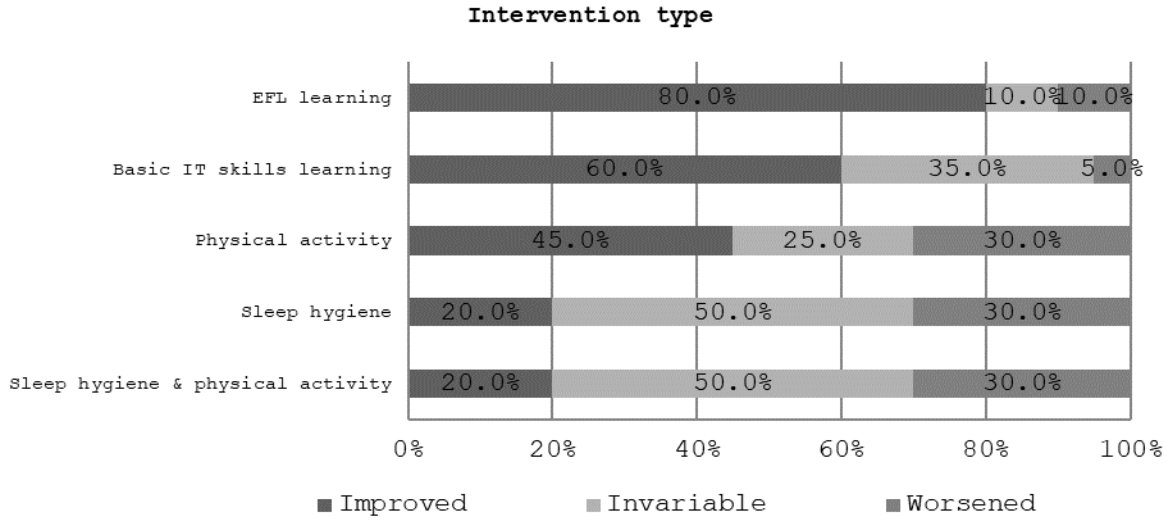


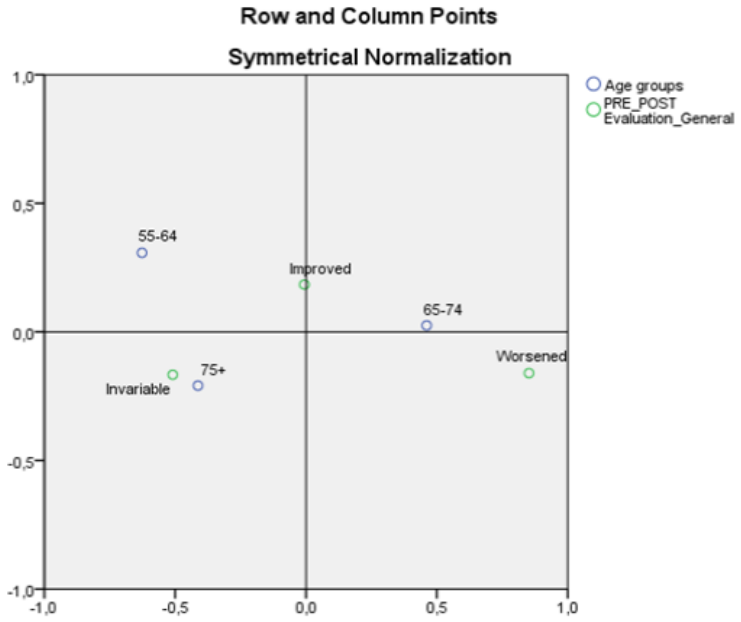
Table 3 displays the post-intervention satisfactory performance on the specialised lexicon tests across variables (i.e. age group; educational level; intervention type).

Table 3: Post-intervention satisfactory specialised lexicon tests performance across variables

Variables	Post-intervention (60% or higher)
55-64	17.7%
65-74	56.5%
75+	25.8%
up to 9 education years	33.9%
9+ education years	66.1%
EFL learning	14.5%
Basic IT skills learning	32.3%
Physical activity	24.2%
Sleep hygiene	14.5%
Sleep hygiene & physical activity	14.5%

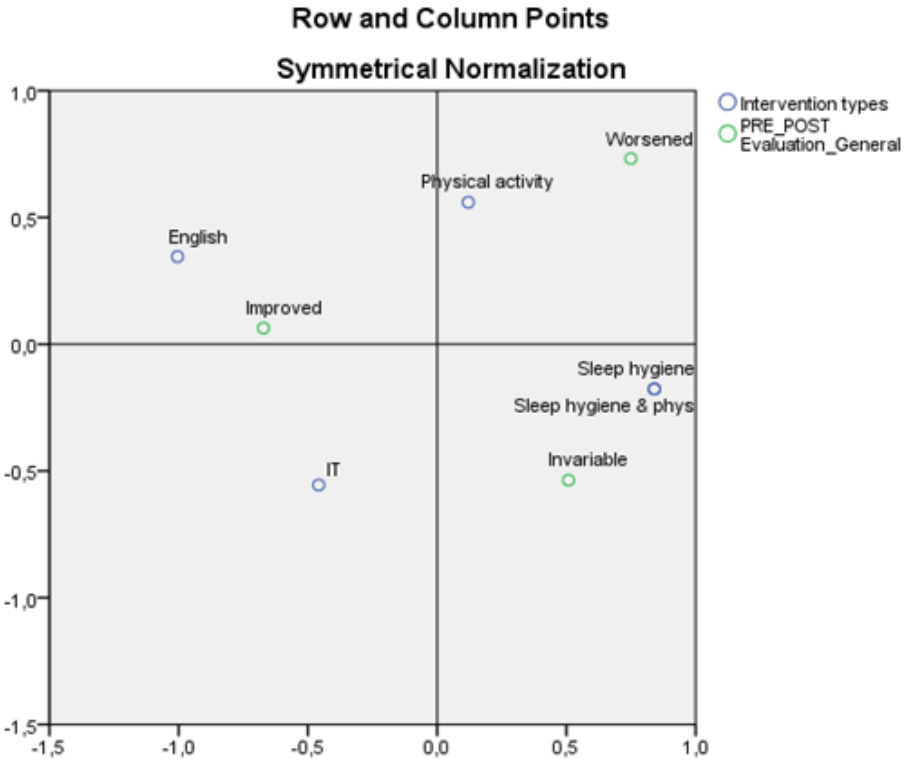
In order to assess the correlations between the variables under consideration and create graphical representations of the variables, further data processing and analysis software were used.

Graph 2: Two-dimensional symmetry diagram of age groups and pre-post evaluation on the GLT



To examine the relationship between variables and their interactions, Correspondence Analysis was conducted with the SPSS 25.0 (IBM Inc., Armonk, NY) statistical software. Additionally, a Multiple Correspondence Analysis was conducted with the Méthode d' Analyse de Données (MAD) software (Karapistolis, 2002). The MAD software was used in order to apply multivariate factor analysis. We used the method of Hierarchical Cluster Analysis (CAH)(see graphs 2 & 3).

Graph 3: Two-dimensional symmetry diagram of intervention type and pre-post evaluation on the GLT



Correspondence Analysis (Graphs 2 & 3) revealed that:

- there was a contrast between the 65-74 on the one hand and the 55-64 and 75+ age groups on the other
- there was a contrast between improved on the one hand and invariable and worsened on the other
- ages 65-74 did not improve, while ages 75+ were invariable
- there was a contrast between the EFL learning intervention on the one hand and action interventions on the other; also, EFL and IT learning contributed to performance improvement, which was not the case for sleep interventions.

The multivariate factor analysis (MAD) revealed that:

- men, aged 55-64, with over 9 years of education, improved in EFL and IT
- men, aged 65-74, with over 9 years of education, improved in EFL
- women, aged 65-74, improved in IT
- women, aged 65-74 and over 75 years, with up to 9 years of education, were either invariable or did not improve in physical activity, sleep hygiene, and sleep hygiene & physical activity

Discussion

The originality of our research lay on the fact that we implemented preventive non-pharmacological interventions which activated the cognition or the physical activity in our MCI participants for the benefit of their verbal memory.

FL and basic IT skills learning contributed to the improvement or maintenance of the cognitive status of MCI older adults more than interventions involving physical action. Apparently, cognitively challenging processes enhanced the performance of the participants on the lexical decision tests. On the contrary, because the physical activity and sleep hygiene interventions were related to actions rather than speech, they would be unlikely to activate verbal memory. Another finding of our research was that the factors of age and educational level have had an impact both on the retrieval ability and the reinforcement of the general mental vocabulary.

Our findings are in line with recent research (Wu, 2016) on the mental lexicon and semantic models: brain imaging has shown that the processing of object and action words is neurally separable, given that the processing of words from different grammatical categories apparently engages partially distinct neural networks. In general, our results provide encouraging evidence as to the feasibility of MCI older adult reintegration. Our seniors' performance on tests assessing both the general lexicon and specialised acquired lexicon has shown that they can be actively re-involved in their social environment because they respond to intervention activities. The attendees themselves believe that their participation in such programmes is meaningful and affects their daily routine positively because they are engaged in activities with people in a similar condition, are relieved from inactivity, are socially and emotionally aroused, learn new things, and acquire new habits.

If cognitively demanding interventions, such as the ones conducted during our research, combined with targeted physical activity and/or sleep hygiene, then the results might be even more encouraging. Recent research has focused on the positive effects of the synchronisation of mobility and cognition programmes for the cognitive benefit of MCI older adults (Karssemeijer et al., 2017; Lipardo & Tsang, 2018; Montero-Odasso et al., 2018).

Our study could not be void of limitations, its main drawback being the small sample sizes. The small sample number was due to the limitations of the specific study descriptors; we were required to confine our research to a certain number of individuals and analyse these limited data, with the purpose of expanding and replicating them in a future study. Another issue to stress was the participants' intervention acquaintance: many of them – concurrently with our research – attended other cognitive stimulation programmes at the day care units, meaning they were trained people. Additionally, they were recruited from a cohort of individuals who are generally open to research, as various experimental studies are frequently conducted at the day care units. Nonetheless, we are convinced that this research could be replicated in the future, on larger samples and probably with improved paradigms, in order to verify these primary results.

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