

# INTERPLAY OF COGNITIVE EFFICIENCY, COGNITIVE ABILITY AND MOTIVATION

**Bruna Pikš\***

MEI:CogSci – University of Ljubljana  
Ljubljana, Slovenia

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## ABSTRACT

The current body of research often focuses on the problem of cognitive decline through ageing. People adapt to these changes of cognitive resources by using brain reserve. An overview of results of different studies on how cognitive abilities of older adults decline highlights high variability of conclusions and sometimes contradiction but it has been shown older adults can be as good as or even better than younger participants in specific domains. Among others, personal meaningfulness of a situation and closeness to the researcher can be strong factors when assessing cognitive abilities and the aim of this paper was to research how these effect cognitive efficiency.

In the pilot study we eliminated the factor of laboratory setting and checked how cognitive efficiency and abilities change in relation to motivation. Forty-eight participants, divided into two age groups, were asked to pass a proverb interpretation test. The results showed that participant's subjective view on the researcher, perceived closeness, correlated with the adequacy in proverb interpretation. Both groups scored higher on adequacy of interpretation when they perceived to be close to the researcher. The younger adults outperformed the older but those in the older adults' group, who felt to be close to the researcher scored as well as younger adults who didn't perceived to be close to the researcher. This motivational reserve might play a role in assessing cognitive abilities and pathologies that affect the outcome of neuropsychological tests.

## KEY WORDS

cognitive ability, cognitive decline, motivational reserve, closeness, proverb interpretation task

## CLASSIFICATION

APA: 2227, 2340, 2343, 2360, 2720, 2860

JEL: Z19

\*Corresponding author, *η*: [bruna.piks@gmail.com](mailto:bruna.piks@gmail.com) +386 31 407 077,  
Ulica bratov Učakar 130, SI – 1000 Ljubljana, Slovenia

## INTRODUCTION

Cognitive decline often accompanies normal ageing, however not all cognitive functions seem to decline at the same rate nor simultaneously [1]. On one hand, increasing impairments through ageing are seen in fluid intelligence (perception, processing accuracy, speed of processing, reaction time, the encoding of new memories into episodic memory, the ability to learn new things, the recall information from long term memory, the capacity of working memory, executive control, selective attention, and inhibition of distracting information) which is mostly biologically and genetically determined. On the other hand, crystalline intelligence (verbal knowledge, comprehension, autobiographical memories, emotional processes, strategies of processing, learned skills, occupational skills) can not only stay stable with age but may even improve. Since this knowledge is able to compensate for decline in the cognitive pragmatics, cognitive decline has little impact on everyday life. However, still differences in performance between young and elderly increase with task complexity [2], especially in laboratory and academic settings.

Many developmental research show that basic cognitive abilities decline with age, however, there are inconsistent results. On one side, studies on theory of mind (TOM) show superiority of older adults in their ability to attribute mental states to self and others as well as in predicting and explaining behavior. In first study of TOM in normal ageing [3] they suggested that despite decrease in performance on tasks with nonmental content the performance in TOM tasks (understanding double bluffs, mistakes, persuasions, and white lies) remains intact or may even improve with coming of age. In their experiment elderly group outperformed the younger on TOM stories task. However, these results were not replicated by Maylor, Moulson, Muncer, and Taylor [4] who found age-related decline in mental state based inferences. Another research [5] revealed age-related changes in older adult's performance on cognitive TOM stories task while their results in affective TOM task show that older adults performed nearly the same as the young adults. Many other research show an age-related decline of TOM [6-8]. Contradicting results might be explained by various factors, one of such being unclear differentiation of the subcomponents of TOM, differences in memory load that TOM tasks require, or different definitions of "old-age" [5].

Stability and increase in efficiency is often found in social cognitive functioning. Everyday problem solving was shown to increase with age, with older adults outperforming the younger [9]. In ecologically relevant contexts age-related declines in cognitive performance may no longer be observed [10]. Older adults were also reported to endorse more effective problem solving in comparison to middle-aged and younger adults [11]. Marsiske and Willis [12] supported the idea of multidimensionality of everyday problem solving. Based on older adults' reporting about having difficulties with tasks of cognition in a laboratory setting while feeling apparent efficacy managing everyday lives, Marsiske and Willis pointed out "an intuitive paradox". Later it was suggested, this paradox might exist because of motivation [13]. Since cognitive decline exhibited by adults in most of their cognitive abilities contradicts their sociomotivational increase in perspective taking in older age, they presumed it might be so because elderly are more motivated to perform better in certain perspective-taking tasks.

## COGNITIVE AGEING

Theories in general prefer to explain cognitive decline by biological factors. First hypothesis is based on a correlation between age-related changes in cognition and speed of processing is

a *general slowing hypothesis* [14]. It holds that at least some of the age-related effects on cognition are a consequence of decreased speed of processing.

Second is *inhibitory deficit theory* [15] which presumes that age differences in cognition arise from reduced working memory capacity. According to this hypothesis decrements in cognition that are tested by tasks typically referred to as frontal lobe tasks are related to inability to ignore irrelevant information in the environment while subjects are focusing on the desired goal [16]. *Frontal lobe hypothesis* with a localizationist approach claims that a prefrontal deterioration in ageing drives cognitive decline [17, 18]. It predicts a selective decline of functions which depend on frontal regions and presumes also that other functions independent from frontal lobe are spared [19]. Cognitive processes subserved by the frontal lobe are one of the first to exhibit a decline with increasing age [20].

The third is the *sensory deficit hypothesis* of ageing which argues that changes in sensation are responsible for the changes in cognitive efficiency [21]. Sensory deficit is supposed to impair performance of subjects performing a task related to general intelligence. However, there were opposing reports to this theory where they found middle-aged adults performing even better in cognitive tests in low acuity condition [22]. Conflicting findings may be a result of different cognitive resource adjustments elicited by different methods.

## **ADAPTIVE ASPECTS OF BEHAVIOR**

One of components of adaptive functioning within the context of social cognitive functioning is selectivity in allocation of cognitive resources [23]. Baltes [24] gave an example of a general theory of life span development. Metatheory *Selective optimization with compensation* (SOC) [24] represents a general model of effective adaptation to biological, psychological and socioeconomic changes in life. Adaptation of individual depends on sociocultural context, individual resources, and personal preferences. In advanced age this adaptation and balance between gains and losses could be achieved by the three component processes: selection of domains important to an individual, optimization of resources and aids that facilitate success in those domains, compensation of the losses in those domains. However, despite contribution to successful ageing it becomes difficult for older adults to engage in SOC strategies due to resource decline [25].

Another theory is *Selective engagement hypothesis* [23] which argues that there is more selectivity in older adults' engagement of cognitive resources. Selectivity is determined by personal relevance, meaningfulness of a situation – that is, older adults would allocate more cognitive resources into tasks with more personal meaning. Hess, Rosenberg and Walters [26] used impression formation task to examine ageing-related selectivity. By varying personal relevance of two motivational variables; the context and behavioral information, they influenced the recall of consistent and inconsistent behaviors of older adults. Elderly were better in recalling inconsistent over consistent behaviors when they were expected to be held accountable for their impression. In experiment of impression formation, in situation where message relevance was high, older adults' attitude toward a lawmaker was independent of his likability. Hess et. al. [26] concluded that older adults' thinking reflected a type of heuristic processing which reflects selective engagement in the task and not necessarily reduction in resources and skills. They have also shown that inconsistency effect in recall of older adults is associated with their resource-consuming elaborative processing of behaviors incongruent with expectations.

## **REDUCTIONS IN COGNITIVE RESOURCES, SELECTIVITY IN COGNITIVE RESOURCES ENGAGEMENT AND MOTIVATIONAL RESERVE**

Hess [23] highlighted the studying of cognitive functioning from a social cognitive perspective. He presumed energy consumption affects/mediates older adults' engaging in effortful processing. Resource-demanding social judgment processes depend on shifting goals of the resources and are not a mere consequence of variations of these cognitive resources. Changes in personal resources influence intrinsic motivational factors that are associated with everyday behavior and higher personal need for structure [27]. In other words, elderly show a greater need for structure if they are in poor health, in low ability, etc. which lead to a diminished engagement in cognitive and social activities [28]. In their research they found the need for structure only influencing older adult's performance in a high relevance condition which suggests that in adults who are in low need for structure the selectivity effect would be most evident. Similarly, in another research at low levels of motivation age differences were visible in the nature of processing [29]. Experiment was designed to make judgments based on scenarios containing informations that were either easily to process and superficial or complex and resource-demanding. Consistent with selective engagement hypothesis, older adults reported less interest in a scenario where their processing was less likely to be influenced by difficult-to-process information and exhibited behavior suggestive of more analytic processing when they reported higher level of engagement.

Decrease in the use of SOC by the elderly has been reported in empirical studies [30-32]. Approaching very old age might operate as a constraint on the use of SOC-related behaviors by limitation of internal or external resources restricting the range of possible alternative goals and domains of functioning of elderly people [31]. Their research showed a negative correlation between chronological age and self-reported SOC. In a longitudinal study [32] a linear decrease in the availability and efficiency of action resources was observed over the age range studied while compensatory efforts only started to decline at the age of 70 after previous constant increase.

It was repeatedly observed that the degree of brain pathology is not directly related to the clinical manifestation of that damage which gave rise to the idea brain reserve [33]. Brain reserve is also used by healthy individuals who cope with demanding tasks.

A type of brain reserve is motivational reserve which reflects motivational abilities that enable an individual to surpass neuropathological damage to some extent [34] in order the subject to function as before the damage. They include variables important for the implementation of personal goals [35] such as action planning and goal orientation [34]. It has been assumed that due to the motivational abilities the number of synaptic connections increases and thus strengthens pathways that compensate for the disrupted brain networks.

## **PROVERB INTERPRETATION TASK**

Age-related decline is seen in cognitive abilities such as executive functions (EF) [20], abstract reasoning being one of its subcomponents [36]. A recognized instrument to evaluate abstract reasoning is the test of proverbs which we used in our pilot study.

In human speech we use non-literal expressions and the ability to interpret their meaning is essential if one wants to engage in successful interactive social communication. Direct literal interpretation would lead to misunderstanding. To test understanding of the non-literal expressions proverbs are used in a clinical test where subjects are asked to interpret the meaning of the proverb. Goldstein characterized this abstract attitude where "we transgress the immediately given specific aspect or sense impression; we abstract from particular properties. We detach ourselves from the given impression, and the individual thing represents to us an accidental or representative of a category." [21]. Non-literal understanding

of figurative expression might demand a suppression of the literal interpretation [37] which demands more engagement and motivation to achieve.

## **METHODS**

### **PARTICIPANTS**

Participants were not aware of the real subject of the study however they agreed to participate in a test of proverb interpretation, pretext under which the test was presented. Participants were assigned to two age groups: younger adults (YA) and older adults (OA). Exclusion criteria for OA – retired participants, was incapability of living independently. Only retired adults who live on their own, outside retirement homes, were included in the research. In group YA, only those who were employed at the time of testing were included in the research.

The mean number of years of education for group YA was 14,8 (range 12 to 21 years). This group consisted of 24 subjects (10 men and 14 women) aged 26 to 67 years (mean 46,5 years and standard deviation 10,18 years).

The mean number of years of education for group OA was 13,4 (range 8 to 21 years). This group consisted of 24 subjects (2 men and 22 women) aged 57 to 77 years (mean 64,2 years and standard deviation 5,50 years).

### **PROCEDURE**

Testing was carried out in environment they found comfortable and familiar with. First group of OA was tested in a center of activities for retired adults, where they regularly visit different daily activities. The testing was carried out during the time they usually have sporting activities on schedule. They were tested in groups of 9-13 individuals at the same time, with some short breaks when they could drink water. Testing lasted from 45min to 1 hour. They knew each other and were well familiar also with the room. Second group YA was tested at home.

All subjects were presented a test with different short tasks printed on. Subjects first had to complete the odd number sequence. Second task was added to check heuristic thinking and as the third proverb interpretation task followed.

### **STIMULUS SELECTION**

Task where proverbs had to be interpreted was created by the author and it comprised out of 20 items. Ten were part of Slovenian cultural heritage and the remaining 10 were from foreign origin (English, Latin, Indian, etc.). Proverbs with at least one metaphorical expression were included with the aim that the demand on the ability to provide an abstract interpretation of figurative language would be maximized. The aim was to choose proverbs of mixed familiarity, thus in the test proverbs used often in media were included as much as proverbs which are not often found in everyday usage.

### **PROVERB INTERPRETATION TASK**

The proverb interpretation task consisted of three parts. First part of the task assessed interpretation of each proverb. A short explanation was necessary to show understanding of the figurative language. We marked as correct all answers that exhibited correct interpretation whether in one sentence or one phrase, since sometimes a proverb could be paraphrased in a single word. Subjects were instructed to write non-literal meaning by themselves, no response alternatives were offered.

The second part of the task assessed familiarity and agreement ratings for each proverb. For this purpose ranging in a shape of a five point-response scale ranging from 1 – “I have never read or heard this proverb before” to 5 – “I have frequently read or heard this proverb and I use it in my everyday life” was used. For agreement rating the same scale was used, five-point response scale rating marked 1 – “I cannot connect to the proverb’s message and I do not agree with it” to 5 – “I completely agree with the proverb and I can find connections to my life”.

## **SCORING SYSTEM FOR PROVERB INTERPRETATION**

When assessing proverb interpretations the choices of proverbs and methods for analyzing are non-standardized and arbitrary [38]. Measuring proverb interpretations is sometimes based on their abstractness and concreteness [21]. On the other side investigators suggest literalness as the variable that should be measured [39]. They concluded that intelligence and the ability to respond abstractly do not affect literalness of proverb interpretation and that concreteness depends too much on intelligence.

A categorical system for scoring similar to Hertler, Chapman and Chapman [39] was created to assess the quality of interpretations of the proverbs in this pilot study. Scoring principles for literalness in responses ranged from 0 to 2 points for a proverb correctly explained.

The proverb interpretation was attributed 0 points in the following cases:

1. The answer was “I don’t know” or there was no response.
2. There was only a reference to the subject’s personal experience.
3. There was no relationship to the literal meaning or the interpretation.
4. There was only a repetition of the proverb or a part of the proverb.
5. The answer was a single word that did not have any relationship to the proverb or its interpretation.

The proverb interpretation was attributed 1 point if:

1. The answer did include at least a synonym for a symbol in the proverb.
2. The answer gave an abstract repetition of at least a part of the proverb.

The proverb interpretation was attributed 2 points when:

1. The answer gave an abstract meaning of the proverb with semantic associates for the symbols from the proverb.

## **RESULTS**

### **NUMBER SEQUENCE AND HEURISTIC THINKING**

All subjects in the group YA filled in the number sequence correctly, and the mean adequacy score for the OA group was 0,79 ( standard deviation 0,415). The analysis found that group OA had statistically significantly lower level of success in completing the number sequence ( $t(23) = 2,46, p = 0.022$ ).

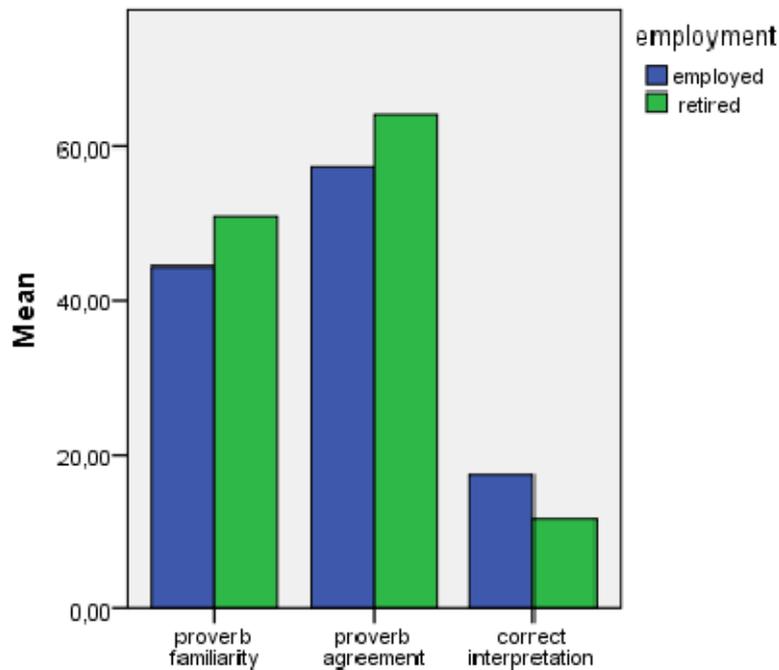
Both groups A and OA scored the same number of correct answers ( $N = 2$  in YA and  $N = 2$  in OA group) in heuristic’s thinking task.

### **PROVERB COMPREHENSION, FAMILIARITY AND AGREEMENT**

Proverbs were graded form 0 to 2 points, therefore 40 was the highest score possible. In group YA the mean score for all the proverbs was 17,4 (standard deviation 8,61) and the mean score for the group OA was 11,7 (standard deviation 7,11). The t-test comparing the scores of YA and OA group was significant ( $t = 2,488, p = 0,017$ ), suggesting that the YA group produced more adequate responses than the OA group.

Familiarity with the proverbs was graded on a five-point-rate scale and thus the total amount of points was 100. Analysis of the ranging of the familiarity of the proverbs found the mean score of the group YA was 44.46 (standard deviation 9,95) while for the group OA it was 51.04 (standard deviation 12,56). The t-test comparing the scores was significant ( $t = -2,013$ ,  $p = 0,05$ ), implying that the OA group was more familiar with the proverbs than the group A.

Agreement with the proverbs was graded on a five-point-rate scale with the total amount of possible points being 100. For the group A the mean score was 57,46 and standard deviation 13,89 while for the group OA the mean score was 64,21 and standard deviation 13,06. The t-test showed a significant difference in agreement scale between the two groups ( $t = -1,734$ ,  $p = 0,09$ ), suggesting that the OA group agrees significantly more with the proverbs than the group A.



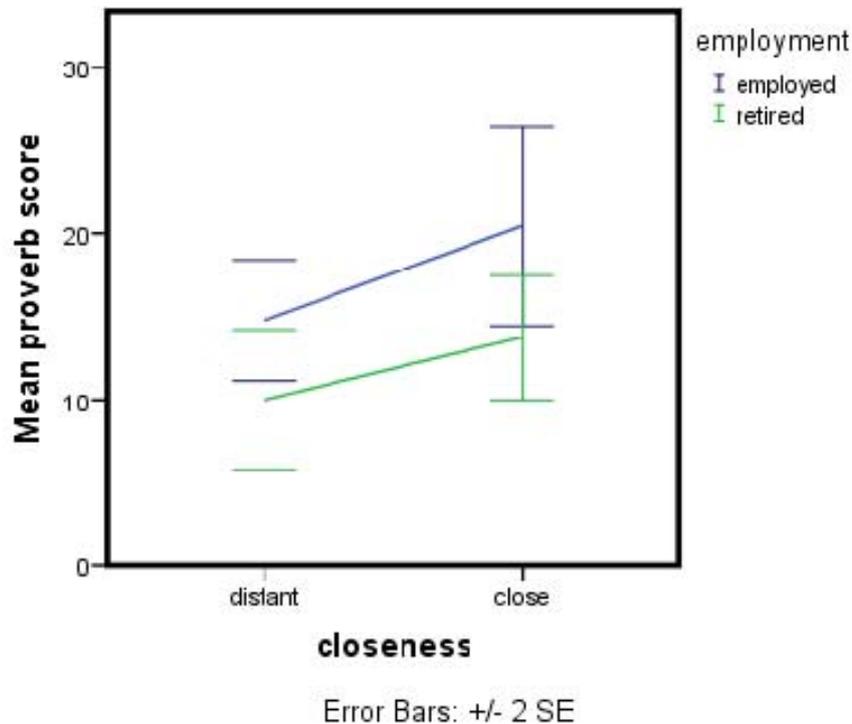
**Figure 1.** Proverb familiarity, agreement and comprehension comparison between two age groups.

### CLOSENESS TO THE RESEARCHER

Considering ratings of relationship of the experimenter to the subject there were no statistically significant differences. In group A (employed subjects) the analysis showed that 11 subject rated the experimenter close to them, being friendly and approachable, while other 13 participants in this group stated experimenter rather professional and not close to them or felt indifferent. In OA (retired subjects) group the same number of participants rated the researcher rather close to them ( $N = 11$ ) and distant and professional ( $N = 13$ ). None of the variables (age, sex, education, employment) had an effect to closeness.

Participants' subjective opinion about the closeness to the researcher correlated with the adequacy of proverb interpretation. From Figure 1, which shows two independent variables (employment and preception of closeness) and one dependent (score in the test), it is seen that employed younger participants scored more points in the proverb interpretation task in comparison to the older retired participants. A univariate analysis of variance tested the effects of perceived closeness to the score. Results indicate that the perception of Closeness significantly effected score in the proverb interpretation task ( $F(1,48) = 4,485$ ,  $p = 0,040$ ). A

significant difference was found between the two age groups when comparing their score. Employment therefore had a significant effect ( $F(1,48) = 6,691, p=0,013$ ). On the other side, interaction Closeness  $\times$  Employment was not significant ( $F(1,48) = 0,194, p = 0,662$ ), indicating the two groups are not responding significantly different in test when the closeness condition is taken into account.



**Figure 2.** Adequacy of proverb interpretation (mean proverb score) of the two groups of participants in relation to their closeness to the researcher.

For further research the difference between subjects within the two groups would be interesting – retired subjects who perceived to be close to the researcher ( $N = 11$ ) vs. the employed subjects who did not perceive to be close to the researcher ( $N = 13$ ). Oneway ANOVA analysis showed no significant difference in score in proverb interpretation task ( $t(22) = 0,398, p = 0,694$ ). The latter came as a nice surprise and would be worthwhile of further investigation.

## DISCUSSION

The present study aimed to assess different effects on proverb comprehension with potential contributions of closeness to the researcher. The scoring system used in this study appears to be a useful tool however there might be some disadvantages. In cases when subjects failed to provide an abstract interpretation, it was difficult to interpret what they were doing. The problem with the proverb test is also its complexity and it involves hypothesized cognitive processes [38]. Providing inadequate interpretation of proverbs may happen due to various reasons. Subjects may not have recognized the proverb or had speech production problems. Familiarity in some cases did not play a role in successful interpretation; it occurred that subjects rated high familiarity with the proverb and failed to provide an adequate interpretation and vice versa. It is necessary to stress again that the proverb test was designed especially for the purpose of this pilot study and it was not a previously established test. Therefore a lot of improvements are possible in this area.

The present pilot study confirmed past research indicating that cognitive abilities decline with age however some stay unchanged or may even improve. Closeness was not manipulated but was still monitored and it proved that participants who felt closer to the researcher, finding her approachable and open to connect, performed better in the proverb interpretation task. On the other side, participants who were indifferent or found the researcher rather distant and not close to them, scored lower in the test. On average, younger subjects outperformed the older, but it came as a surprise that older participants who perceived to be close to the researcher did not score significantly lower on the test in comparison to the younger adults who did not perceive to be close to the researcher. If closeness increases motivation of older adults to a comparable level as younger participants, that they become more cognitively efficient, ways of manipulation could be developed in future in order to enhance older adults' cognitive abilities. By understanding cognitive networks in the background not only enhancing abilities but also preserving them into older age might become possible. For the time being, this knowledge might be worthwhile taking into account in neuropsychological assessment for ecologically more valid results. Other interpretations are possible. One might be that participants who did well in the test felt it and this could have boosted their confidence. This then made them more open to connecting to new people in this case, the researcher.

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## VEZANOST KOGNITIVNE UČINKOVITOSTI, KOGNITIVNE SPOSOBNOSTI I MOTIVACIJE

B. Pikš

MEI:CogSci – Sveučilište u Ljubljani  
Ljubljana, Slovenija

### SAŽETAK

Suvremena istraživanja često se fokusiraju na problem smanjivanja kognitivnih sposobnosti uslijed starenja. Ljudi se prilagođavaju promjenama kognitivnih resursa korištenjem rezervi u mozgu. U radu je dan pregled rezultata različitih istraživanja o smanjivanju kognitivnih sposobnosti starijih osoba, uz istaknutu znatnu varijabilnost a katkad i kontradiktornost zaključaka. No, također se pokazuje kako stariji mogu biti jednako dobri ili i bolji od mlađih sudionika u specifičnim domenama. Između ostalog, osobni smisao neke situacije i bliskost s istraživačem mogu biti važni faktori pri procjenjivanju kognitivnih sposobnosti. Cilj ovog rada je istražiti kako ti faktori utječu na kognitivnu učinkovitost.

U pilot istraživanju eliminirani su faktori laboratorijskog postava te je provjereno kako se kognitivna učinkovitost i sposobnosti mijenjaju u odnosu na motivaciju. 48 sudionika, podijeljenih u dvije dobne skupine, prolazili su test interpretacije poslovice. Rezultati su pokazali kako su ispitanikov subjektivni doživljaj istraživača i doživljena bliskost, u korelaciji s prikladnošću interpretacije poslovice. Obje skupine postizale su bolje rezultate u prikladnosti interpretacija kad su se smatrale bliskijima istraživaču. Mlađa skupina nadmašivala je stariju. Ali oni u starijoj skupini, koji su se smatrali bliskima istraživaču, postizali su rezultate kao i oni u mlađoj skupini koji se nisu smatrali bliskima istraživaču. Ova motivacijska rezerva može biti značajna u procjenjivanju kognitivnih sposobnosti i patologija koje utječu na rezultat neuropsiholoških testova.

### KLJUČNE RIJEČI

kognitivna sposobnost, kognitivni pad, rezerva motivacije, bliskost, zadatak interpretiranja poslovice