Handout

Microeconometrics - Eric Bonsang

Inès Valette-Aïouaz and Lubin Bénéteau

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2025 first semester Université Paris-Dauphine – PSL

Contents

1 Introduction

As populations in most developed countries are ageing, people are spending an increasingly large portion of their lives in retirement. On one hand, this trend raises concerns about the financial sustainability of pension systems. On the other hand, it also raises questions about the impact of retirement on individuals, particularly in terms of health. Health effects are especially important because they can indirectly affect the financial burden of pension systems. In particular, there is growing concern that leaving the workforce may accelerate cognitive decline. If retirement contributes to worsening health, this could lead to a long-term increase in healthcare expenditures. Such potential consequences should be taken into account when considering reforms to raise the minimum retirement age.

Previous research has shown that retirees tend to perform worse on memory and other cognitive tests than people who are still working. However, it is difficult to know whether retirement causes this decline, or if people with lower cognitive functioning simply retire earlier. Factors such as education, job type, and lifestyle may also influence both retirement decisions and cognitive health.

To address this issue, Bonsang, Adam, and Perelman (2012) propose an instrumental variable (IV) strategy using U.S. panel data from the Health and Retirement Study. Their identification strategy exploits the sharp discontinuities in retirement behavior at the minimum eligibility ages for U.S. Social Security benefits : age 62 (early retirement) and 65 (full benefits). These age thresholds strongly predict retirement, but are assumed to affect cognitive functioning only through retirement status. By combining this IV approach with individual fixed effects to control for time-invariant heterogeneity, the authors aim to estimate the causal effect of retirement on cognition.

The main outcome of interest is a cognitive score based on an episodic memory task: the sum of words correctly recalled immediately and after a short delay, out of a list of 10 common words. The primary explanatory variable is a dummy for being retired for at least one year, which reflects the fact that any cognitive impact of retirement may not be immediate due to adjustment phases like the honeymoon period. The two instruments used are dummy variables for being aged 63 or older, and for having reached the full retirement age plus one year.

The key finding is that retirement has a statistically significant and quantitatively meaningful negative effect on cognitive functioning: retirees score approximately 0.9 points lower on average than similar individuals who continue working. This represents roughly a 10% decline relative to the sample mean. The effect is robust across alternative specifications, including those accounting for retirement duration or heterogeneity by education or gender. Moreover, the authors find that the negative impact appears with a delay and is most pronounced in the early years of retirement, stabilizing thereafter. These results are interpreted as evidence supporting the use it or lose it hypothesis, whereby cognitive abilities deteriorate in the absence of mentally stimulating work-related activities.

Beyond their empirical contribution, the authors highlight broader policy implications. If retirement causally contributes to cognitive decline, then reforms aimed at delaying retirement may yield not only financial but also maybe health-related benefits, reducing the incidence of cognitive impairment and associated long-term care needs. Their findings also lend support to active ageing policies that promote lifelong learning, continued participation in the workforce, and cognitively engaging activities for older adults.

In this report, we follow a similar approach to investigate whether retirement affects cognitive performance. We apply the same methodology to a different dataset. Our goal is to contribute to the broader discussion on how public policies, such as raising the retirement age, might influence not only direct economic outcomes but also indirect outcomes such as the cognitive health of ageing populations.

2 Data

The paper uses longitudinal data from the Health and Retirement Study (HRS) covering the period 1998-2008. The sample includes U.S. individuals aged roughly 50 to 75 and exploits the panel structure to control for individual fixed effects. Retirement status and retirement duration are observed from self-reported labor market information. Cognitive functioning is measured using an episodic memory test based on immediate and delayed word recall. Respondents are asked to memorize a list of ten common words and to recall them immediately and after a short delay. The cognitive score is defined as the sum of correct words recalled in both phases, ranging from 0 to 20. This test is widely used in the gerontological literature and is considered a reliable measure of fluid cognitive abilities. Importantly, it exhibits neither floor nor ceiling effects, ensuring sufficient variability for econometric analysis[1].

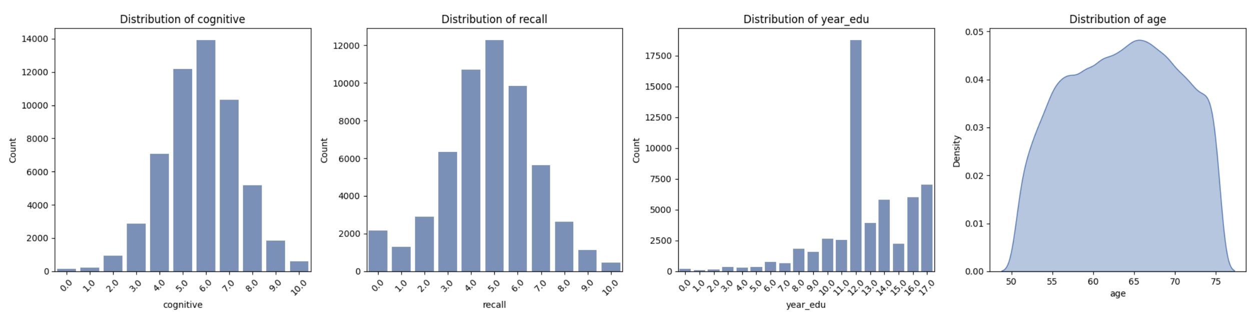

Figure 1: distributions of the main variables

`cognitive` stands for the immediate work recall, it appears that the tested sample remember 5.7 words in average[2]. While `recall` stands for the delayed work recall, in average individuals recalls 4.77 words. In the sample, individuals attend school during 12[3] years in average and they are aged from 50 to 76 (63 in average).

3 Description of the econometric approach

Our aim is to estimate the causal effect of retirement status on Cognitive performance. We faced two main issues : The first one concerns endogeneity: retirement status may be correlated with the error term, leading to biased OLS estimates. The second is potential omitted variable: individual heterogeneity (factors as health issues, accidents, social interactions, proximity to family members,

[1]We produced graphs in appendix to show it.

[2]Data are described in appendix.

[3]Usually in the US people go through this scheme of education: Kindergarten, Elementary School, Middle School, High School from ages 5 to 18, after high school, studies are no longer mandatory

etc.) may be correlated with both cognitive functioning and retirement decision, this can also leads to bias.

In order to solve this two issues we use instrumental variables. On the top of that to face the issue of innate and individual differences between panel respondent, we use fixed effect. This solve an issue and introduce another one since fixed effect biased the estimation (this is due to the nature of our IVs, we use binary ones).

3.1 Model

Structural equation. Cognitive functioning is measured by a score of a cognitive test. In our model, we assume that cognitive functioning (c_{it}), is measured by the score obtained at a cognitive test (described above), depends on retirement status (r_{it}) and a smooth function of age ($f(age_{it} = age + (age)^2)$), along with an error term that can be decomposed into unobserved time-invariant heterogeneity (μ_i) and an idiosyncratic error term (v_{it}). Assuming linear separability, cognitive functioning is given by the following equation:

$$C_{it} = \beta r_{it} + f(\text{age}_{it}) + \mu_i + v_{it}$$

It captures the causal effect β of retirement status r_{it} on cognitive functioning C_{it}, controlling for age and individual fixed effects.

As explain in the introduction of this section, to solve potential omitted variables bias and endogeneity we use instrumental variables and fixed effects.

We will use two instrumentals variables, Z_{62it} and Z_{65it}. Z_{62it} exploits the eligibility to early social security benefits in the US, it is a dummy variable equal to 1 if the age of 62+1 is reached. Z_{65it} use the eligibility to full social benefit from social security. This dummy is equal to 1 when age of 65+1 is reached. The (+1) year is used to take into account the "honeymoon phase" where retired individuals are kept busy for a moment (few months in average) which introduce a lag in the decrease of cognition.

Our instruments must satisfy these two assumptions:

- **Relevance:** Z_{62it} is correlated with r_{it} and Z_{65it} is correlated with r_{it} (i.e., $Cov(Z_{62it}, r_{it)} \neq 0$ et pour $Cov(Z_{65it}, r_{it}) \neq 0$).
- **Exclusion restriction**[1]**:** $Cov(Z_{62it}, V_{it}) = 0$ and $Cov(Z_{65it}, V_{it}) = 0$.
  - the instrument is as god as randomly assigned (CIA : $\{Y_{0i}, Y_{1i}\} \perp\!\!\!\perp r_{it} \mid f(age_{it})$)
  - the instrument has no effect on outcomes other than through the first-stage channel.

First-stage equation. Here we are looking for the effect of instrumental variables on the retirement status. Analytically :

$$r_{it} = \pi_1 \, Z_{62it} + \pi_2 \, Z_{it} + f(\text{age})_{it}) + \mu_i + \epsilon_{1it}$$

ϵ_{1it} is the error term of the first stage equation

[1]Concerning the exclusion restriction assumption, we judge plausible the fact that retirement ages (respectively 62 and 65) does not influence the cognition. Indeed, we can consider that at age of 62 is not a legal threshold for anything else than legal retirement. Nevertheless it could be discussed for the age of 65 since it is also the threshold for Medicaid availability. But it is not likely that the respondents are waiting this age to access to health care. Hence we can consider the exclusion restriction as valid and we can use our IVs on this base.

Reduced form equation. Here we are looking for the effect of instrumental variables on the cognition. Analytically :

$$C_{it} = \rho_1 \, Z_{62it} + \rho_2 \, Z_{it} + f(\text{age})_{it}) + \mu_i + \epsilon_{2it}$$

3.2 Inference and clustered standard errors

All regressions are estimated using individual fixed effects to account for time invariant unobserved heterogeneity. Standard errors are clustered at the individual level. This choice is motivated by the panel structure of the data, as observations for a given individual are likely to exhibit serial correlation over time. Ignoring this would lead to underestimation of standards errors. Clustering at the individual level maintain independence across individuals. This approach is standard in panel data settings.

3.3 Instruments relevance

To evaluate the relevance of our instruments, we conducted a F-test. We use two models, one restricted (without instruments) and one unrestricted (with IVs).

- **Unrestricted first stage (with instruments):**

$$r_{it} = \pi_1 Z_{62it} + \pi_2 Z_{65it} + f(\text{age}_{it}) + \mu_i + \varepsilon_{1it}.$$

- **Restricted first stage (excluding the instruments):**

$$r_{it} = f(\text{age}_{it}) + \mu_i + \varepsilon_{1it}.$$

We then compute the joint F-statistic testing the null hypothesis

$$H_0 : \pi_1 = \pi_2 = 0,$$

that is, the joint significance of the excluded instruments Z_{62it} and Z_{65it} in the first-stage regression.

The classical F-statistic is given by[1]

$$F = \frac{(SSR_r - SSR_u)/q}{SSR_u/(N - k_u)}.$$

Equivalently, the F-statistic can be written in terms of R^2 as

$$F = \frac{(R_u^2 - R_r^2)/q}{(1 - R_u^2)/(N - k_u)}.$$

A know rule of thumb in economics suppose to reject the hypothesis to have weak instruments when the above F-test exceed 10.

[1]Where:

- $q = 2$ the number of excluded instruments.
- SSR_r and SSR_u be the sums of squared residuals from the restricted and unrestricted models.
- k_u the number of regressors in the unrestricted model (including age terms and fixed effects)
- N the number of observations.

Second stage equation. This estimates the causal effect of retirement on cognition using predicted values of $\hat{r_{it}}$ of the first stage (2SLS).

$$C_{it} = \beta\,\widehat{r_{it}} + f(age_{it}) + \mu_i + v_{it}$$

3.4 Overidentification test

In general, the exogeneity assumption required for instrumental variables cannot be tested directly. However, when the number of instruments exceeds the number of endogenous regressors, the model is overidentified and it becomes possible to test the joint validity of the instruments.

Consider the following structural equation:

$$C_{it} = \beta_0 + \beta_1 r_{it} + \beta_2 x_{it} + \varepsilon_{it}, \tag{1}$$

where r_{it} is endogenous.

Assume that we dispose of two instruments for r_{it}, namely Z_{62it} and Z_{65it}. This implies that equation (1) can be estimated using either instrument separately.

Let $\hat{\beta}_1^{(62)}$ denote the IV estimator of β_1 obtained using only Z_{62it} as an instrument for r_{it}, and let $\hat{\beta}_1^{(65)}$ denote the IV estimator obtained using only Z_{65it}.

If both Z_{62it} and Z_{65it} are valid instruments, that is, if they are exogenous and sufficiently correlated with r_{it}, then both estimators are consistent for β_1:

$$\hat{\beta}_1^{(62)} \xrightarrow{p} \beta_1 \qquad \text{and} \qquad \hat{\beta}_1^{(65)} \xrightarrow{p} \beta_1.$$

Hausman (1978) proposed testing the joint exogeneity of the instruments by exploiting the difference between these two estimators. Under the null hypothesis that both instruments are valid, the difference

$$\hat{\beta}_1^{(62)} - \hat{\beta}_1^{(65)}$$

should converge in probability to zero.

A statistically significant difference between the two estimators provides evidence against the null hypothesis, implying that at least one of the instruments violates the exogeneity condition.However, this test does not allow us to identify which instrument is invalid.

4 Refinement in the model

Education is a key determinant of cognitive performance and is strongly related to the notion of cognition, especially after retirement. We could infer that educated people tends to keep a "cerebral activity" through their past occupation. Failing to account for education, may confound the estimated effect of retirement on cognition. Moreover, the causal effect of retirement may plausibly be heterogeneous across education levels. We therefore allow the retirement effect to vary with years of education.

Structural equation with heterogeneous effects. Let $\widetilde{edu}_i = edu_i - \overline{edu}$ denote years of education centered at its sample mean. We estimate the following structural model:

$$C_{it} = \beta_0 + \beta_1 r_{it} + \beta_2\big(r_{it} \times \widetilde{edu}_i\big) + f(\text{age}_{it}) + \mu_i + \varepsilon_{it},$$

where C_{it} is cognition, r_{it} is retirement status (endogenous), $f(\text{age}_{it})$ is a smooth function of age, and μ_i are individual fixed effects.

Instrumental variables strategy (with centered interactions). Because r_{it} is endogenous, the interaction term $r_{it} \times \widetilde{edu}_i$ is also endogenous. We instrument r_{it} using the age-threshold dummies Z_{62it} and Z_{65it}, and instrument the interaction using the corresponding interacted instruments:

$$r_{it} \leftarrow Z_{62it},\ Z_{65it}, \qquad r_{it} \times \widetilde{edu}_i \leftarrow Z_{62it} \times \widetilde{edu}_i,\ Z_{65it} \times \widetilde{edu}_i.$$

Centering education makes β_1 directly interpretable as the causal effect of retirement at the *average* education level (rather than at $edu_i = 0$), and it reduces collinearity between r_{it} and $r_{it} \times \widetilde{edu}_i$, improving numerical stability.

We estimate the model by two-stage least squares with individual fixed effects: in the first stage, r_{it} and $r_{it} \times \widetilde{edu}_i$ are regressed on the instrument set $\{Z_{62it}, Z_{65it}, Z_{62it} \times \widetilde{edu}_i, Z_{65it} \times \widetilde{edu}_i\}$ and $f(\text{age}_{it})$ (and μ_i), and the fitted values are then used in the second-stage cognition equation.

5 results

5.1 First stage

Table 1: First Stage Regression

	(1) Not working for at least one year
Being 63 year-old or older	0.100*** (21.046)
Having reached the normal age of retirement for at least one year	0.064*** (13.276)
Age in years	0.035*** (7.016)
age2	-0.000 (-0.987)
Constant	-1.690*** (-10.672)
Observations	55330

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The first-stage results indicate that age 63 threshold increases the probability of not working for at least one year by about 10 percentage points while having reached the normal retirement age for at least one year raises this probability by approximately 6.4 percentage points. Both effects are highly significant, which suggests a strong instrument relevance.

Also, `Age in years` and `age2` are not both significant, it could mean that there is no strong nonlinear age pattern beyond the retirement thresholds.

The magnitude and significance of the coefficients indicates a strong first stage, a sign that our instruments are not weak.

5.2 Reduced form

Table 2: Reduced Form Regression

	(1) score
Being 63 year-old or older	-0.106* (-2.441)
Having reached the normal age of retirement for at least one year	-0.034 (-0.774)
Age in years	0.461*** (10.094)
age2	-0.005*** (-12.987)
Constant	0.414 (0.286)
Observations	55330

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Crossing the age 63 threshold is associated with a significant decline in the cognitive score of about 0.11 points, while the effect of having reached the normal retirement age is negative but not significant. Thus, these results suggest that the retirement eligibility thresholds affect cognition, providing reduced-form evidence consistent with a causal impact of retirement on cognitive outcomes.

5.3 Instruments relevance

Table 3: First Stage Regression

	(1) Not working for at least one year
Being 63 year-old or older	0.100*** (21.046)
Having reached the normal age of retirement for at least one year	0.064*** (13.276)
Age in years	0.035*** (7.016)
age2	-0.000 (-0.987)
Constant	-1.690*** (-10.672)
First-stage F-stat	364.787
Observations	55330

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Instrument relevance is strongly supported by the first-stage joint significance test. The F-statistic for the exclusion of the age-based instruments is equal to 364.8, far exceeding conventional thresholds (rule-of-thumb) value of 10. This high F-stats indicates that the retirement eligibility provides strong explanatory power for retirement status, ensuring a strong first stage. We could infer that weak instrument bias is avoided.

5.4 Second stage

Table 4: Second Stage Regression

	(1) score
Not working for at least one year	-0.896**
	(-2.637)
Age in years	0.484***
	(10.555)
age2	-0.005***
	(-13.545)
Constant	-0.854
	(-0.546)
Observations	55330

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The second-stage estimates indicate a significant negative effect of retirement on cognition. Not working for at least one year decreases the cognitive score by 0.90 points, with the effect being significant at the 1% level. These results point to a causal effect of retirement on cognition for compliers, consistent with the LATE interpretation of the IV estimator.

5.5 Overidentification stage

Table 5: Second Stage with Overidentification Test

	(1) score
Not working for at least one year	-0.896**
	(-2.637)
Age in years	0.484***
	(10.555)
age2	-0.005***
	(-13.545)
Constant	-0.854
	(-0.546)
Hausman χ^2	-0.978
Hausman p-value	1.000
Observations	55330

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The overidentification test does not provide evidence against the joint validity of the instruments. The Hausman test comparing the estimates obtained using each instrument separately presents a p-value of 1.00, indicating that the null hypothesis of instrument exogeneity cannot be rejected. This result suggests that the age-based instruments are consistent and affect cognitive outcomes only through their impact on retirement status. Hence, the test supports the exclusion restriction and reinforces the credibility of the IV identification strategy.

5.6 Refinement - Interaction term with education

Table 6: Structural Equation with Heterogeneous Effects

	(1) score
Retirement	-0.961**
	(-2.822)
Retirement x Education	-0.005
	(-0.160)
Age in years	0.487***
	(10.578)
age2	-0.005***
	(-13.517)
Constant	-0.989
	(-0.630)
Observations	55266

t statistics in parentheses
Education is centered at its sample mean.
Instruments include Z62, Z65, and their interactions with education.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The interaction model allows the effect of retirement on cognition to vary with the number of years individual attended school. The coefficient on retirement remains negative and statistically significant, indicating that, at the average level of education of our sample, retirement seems to reduce cognition by about 0.96 points. On the other hand, the interaction between retirement and education is small and not significant, suggesting no evidence of heterogeneity in the retirement effect across education levels. It does mean that whatever the level of education of individuals in the sample, it doesn't affect the cognitive impact on retirement.

6 conclusion

In a nutshell, we showed using an IV method that retirement has a negative effect on individual cognition. This effect occurs with a lag due to the "honeymoon period". This result is also robust to heterogeneity regarding the level of education, which seems not to have have any effect on cognition after retirement.

Public policy insights. We could think that a progressive retirement policy would avoid any abrupt drop in cognition but smooth it throughout time. Also, cognition during the honeymoon phase seems not to drop too much. Then, inciting all retired people to have an activity in a charity related structure would also be a good idea to slower the decrease of cognition.

A Results - overall

Synthesis of results

Table 7: Impact of Retirement on Cognition: IV and Heterogeneous Effects

	(1) First Stage	(2) Reduced Form	(3) Second Stage	(4) Interaction
Being 63 year-old or older	0.100***	-0.106*		
	(21.046)	(-2.441)		
Having reached the normal age of retirement for at least one year	0.064***	-0.034		
	(13.276)	(-0.774)		
Age in years	0.035***	0.461***	0.484***	0.487***
	(7.016)	(10.094)	(10.555)	(10.578)
age2	-0.000	-0.005***	-0.005***	-0.005***
	(-0.987)	(-12.987)	(-13.545)	(-13.517)
Retirement			-0.896**	-0.961**
			(-2.637)	(-2.822)
Retirement x Edu				-0.005
				(-0.160)
Constant	-1.690***	0.414	-0.854	-0.989
	(-10.672)	(0.286)	(-0.546)	(-0.630)
First-stage F-stat	364.787			
Observations	55330	55330	55330	55266

t statistics in parentheses

Note: First stage and reduced form are OLS Fixed Effects. Columns 3 and 4 are 2SLS Fixed Effects.

Education is centered at its sample mean for the interaction model.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results of the table above provide evidence of a negative causal effect of retirement on cognitive performance. First-stage equation estimates show that the age eligibility indicators strongly predict retirement behavior, with a very large F-statistic, rejecting any hypothesis of weak instruments. The reduced-form results indicate that retirement thresholds implies lower cognitive scores, in particular around 62 years. The second-stage IV estimates reveal a negative effect of retirement on cognition, larger in magnitude than the reduced-form coefficients. Finally, allowing for heterogeneous effects by education does not reveal significant variation in the retirement effect on cognition, suggesting a similar impact of retirement across groups. Overall, these findings support the hypothesis that retirement increases cognitive decline.

B Data description

Here is an overview of the data

	(1)				
	mean	sd	min	max	median
id	1.29e+08	1.42e+08	2010	5.03e+08	
year	2002.793	3.436702	1998	2008	
y_int	2002.812	3.436017	1998	2009	
cognitive	5.781945	1.631388	0	10	
recall	4.778366	1.990394	0	10	
woman	.5546177	.4970124	0	1	
year_edu	12.72435	3.051198	0	17	
age	63.57529	6.669881	51	75	
eli2	.603199	.4892385	0	1	
eli3	.4538225	.4978676	0	1	
elib2	.5585577	.4965636	0	1	
elib3	.4075727	.4913874	0	1	
t62	3.702241	4.280348	0	13	
t65	2.139472	3.158311	0	10	
ret	.5046991	.4999824	0	1	
tq	3.317025	4.837686	0	25	
ret1	.4617387	.4985384	0	1	
N	55330				

Variables

Table 8: Description of Variables

Name	**Label**
id	Individual identifier
year	Survey wave
y_int	Year of interview
cognitive	Immediate word recall
recall	Delayed word recall
woman	Woman
year_edu	Number of years of education
age	Age in years
eli2	Being 62 year-old or older
eli3	Having reached the normal age of retirement
elib2	Being 63 year-old or older
elib3	Having reached the normal age of retirement for at least one year
t62	Number of years since 62 year-old
t65	Number of years since the normal age of retirement
ret	Not working
tq	Number of years in retirement
ret1	Not working for at least one year

Ceiling and floor effects?

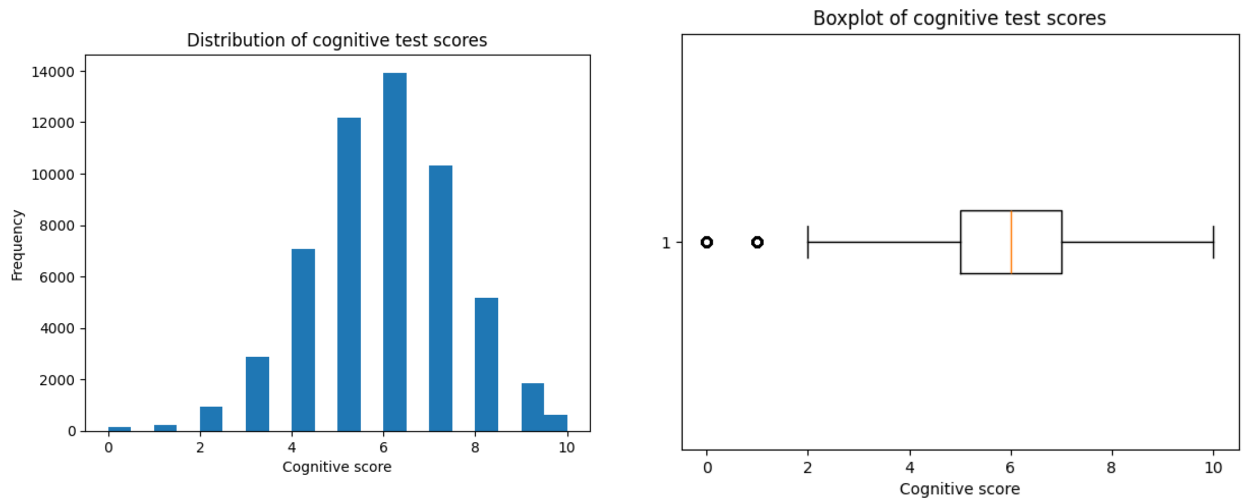

Figure 2: Absence of floor and ceiling effects

There is no evidence of floor or ceiling effect since there no significative concentration of cognitive test score at the levels of 0 and 10. This is confirmed by the boxplot producted justabove.