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WHAT IS MEASURED BY THE PSYCHOMETRIC TOOLS USED FOR DRIVER APTITUDE ASSESSMENT IN POLAND? A RESEARCH REPORT

The safety performance of road drivers requires an improvement of the mechanism of selecting candidates for professional drivers. Unfortunately, it has been common practice until now to design diagnostic methods to reflect the theoretical constructs of traits and abilities considered useful in road traffic. We decided to adopt the opposite, complementary approach and to analyze what the methods used in Polish transport psychology really measure and what theoretical constructs that corresponds to. The results will be treated as a first step towards determining the prognostic validity of these psychometric tools. We tested 300 professional male drivers, aged form 21 to 65 years, belonging to six groups of equal size: victims of collisions, victims of accidents, perpetrators of collisions, perpetrators of accidents, drivers stopped by the police for drunk driving and those who had never been involved in any of the above situations. The analysis concerned 27 indicators taken from nine diagnostic tools commonly used by transport psychologists in Poland. Exploratory factor analysis was performed to determine the latent factor structure of these methods. The Kaiser criterion allowed us to identify the eight-factor solution as the optimal one. The extracted factors are: attention, accuracy in visual perception, mental alertness, sense of community, efficiency of reactiveness and decision making, cognitive abilities (logical induction and grasping analogy), agency, and sensitivity to social approval.

Keywords: transport psychology, diagnostic methods, traffic accident prevention.

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INTRODUCTION

From the earliest days of motor traffic the problem of traffic accidents has existed all over the world and psychological instruments have been sought to reduce their number (Munsterberg, 1913; Nordfjærn & Rundmo, 2013; Wontorczyk, 2011). In Poland alone, for example, 37,046 accidents took place in 2012 in which 3,571 people were killed and 45,792 were injured (Symon, 2013). What is more, it has been observed for many years that about 85% of all traffic accidents are caused by incorrect behavior of vehicle drivers (Markowski, 2014). This points to the urgent need for improving the mechanisms of qualification for using public roads (Oltedal & Rundmo, 2006). One of the largest groups that the number of accidents depends on is professional drivers (Łuczak & Najmiec, 2009). They are obliged to undergo diagnostic examination in certified psychological laboratories. What has been a noticeable problem is the shortage of methods with certain external validity indicators (Łuczak & Najmiec, 2009) – such as accident perpetration – which should be used in the selection of professional drivers (Sommer, Herle, Hausler et al., 2008). There is also a need to systematize the currently used psychometric tools, for example to eliminate their redundancy in diagnostic practice.

RESEARCH PROBLEM AND AIM

Functioning safely as a driver requires certain traits and abilities (Bąk, 2003; Markowski, 2014). The literature worldwide and in Poland most often mentions the following: cognitive abilities (Sommer et al., 2008), sensory abilities (Biela, Kamiński, Manek et al., 1992), personality traits (Clare & Robertson, 2005; Nordfjærn & Rundmo, 2013; Ozkan & Lajunnen, 2006), temperament type (Wontorczyk, 2011), self-esteem (Sundstrom, 2008), as well as emotional and social maturity (Łuczak & Najmiec, 2009; Markowski, 2014).

In the Polish psychology of transport there are studies whose aim is to determine which traits are critical and which are desirable in a driver working, for example, in goods transport. These include the study by Widerszal-Bazyl and collaborators (1998), in which the authors started out from work analysis to propose general categories: sensorimotor skills, abilities, personality traits, and interests. Biela-Warenica (2012) chose a similar path by conducting her analysis using the Lublin Questionnaire of Workplace Analysis (Biela et al., 1992).

A consequence of this approach is the use of a very large number of tools, which stems from the fact that so far the practice has been to select diagnostic methods to match the theoretical constructs regarded as important in the process of assessing aptitude for work as a driver (Bąk, 2004; Najmiec, 2008). In the present study we decided, as it were, to approach the matter from the other side and check what the tools used in the Polish psychology of transport actually measure and to what extent they correspond with the theoretically posited constructs. Our aim, therefore, is to establish what is measured by the tests and questionnaires used in psychological laboratories by transport psychologists in Poland. We treat answering this question as the first step towards establishing the diagnostic and prognostic accuracy of these methods.

METHOD

Measures

Nine tests and questionnaires commonly used by transport psychologists in Poland for the purpose of assessing drivers' professional abilities were applied in the study. They can be grouped into five categories. Personality traits were measured using the Eysenck Personality Questionnaire (EPQ-R; Jaworowska, 2011) and the NEO-FFI by Costa and McCrae as adapted by Zawadzki, Strelau, Szczepaniak, and Śliwińska (1998). In order to measure visual perception accuracy we used the stereoscopic vision test and the dark room test. The abilities of concentrating, dividing, and alternating attention were measured using the Poppelreuter test. To measure mental abilities, we used the standard version of Raven's Standard Progressive Matrices (SPM; Jaworowska & Szustrowa, 2000). Psychomotor skills were tested using the Piórkowski apparatus, an MRK-433 reaction time meter (RTM), and a kinesthesiometer.

The total number of variable indicators generated by these instruments is 27. Table 1 contains detailed information about what they are.

Table 1
A List of Measures

No.	Diagnostic measures
1	NEO-FFI: Neuroticism
2	NEO-FFI: Extraversion
3	NEO-FFI: Openness to Experience
4	NEO-FFI: Agreeableness
5	NEO-FFI: Conscientiousness
6	EPQ-R: Neuroticism
7	EPQ-R: Extraversion
8	EPQ-R: Psychoticism
9	EPQ-R: Social Desirability
10	Stereometer: Stereoscopic vision
11	Dark Room Test: vision in the dark
12	Dark Room Test: sensitivity to glare
13	Poppelreuter Tables Test: the longest series of correctly written numbers
14	Poppelreuter Tables Test: the number of mistakes made in series of numbers written
15	Poppelreuter Tables Test: the total number of correctly written numbers
16	Raven's Standard Progressive Matrices, Set A: noticing continuous patterns
17	Raven's Standard Progressive Matrices, Set B: noticing analogies between pairs of figures
18	Raven's Standard Progressive Matrices, Set C: noticing progressive alterations of figures
19	Raven's Standard Progressive Matrices, Set D: noticing permutations of figures
20	Raven's Standard Progressive Matrices, Set E: resolution of figures into constituent parts
21	Reaction Time Meter: simple reaction time
22	Reaction Time Meter: distribution of simple reaction time
23	Reaction Time Meter: complex reaction time
24	Reaction Time Meter: distribution of complex reaction time
25	Reaction Time Meter: mistakes of complex reaction
26	The Piórkowski Apparatus: Eye-hand coordination
27	Kinesthesiometer: Kinesthetic sensitivity

Sample and Procedure

The analyses used results obtained from 300 professional male drivers aged 21-65 years. The entire sample consisted of six groups, with 50 people in each group: (1) drivers who had never caused or been victims of collisions or accidents and who had never had their driving licences revoked, (2) victims of collisions, (3) victims of accidents, (4) perpetrators of collisions, (5) perpetrators of accidents, (6) drivers stopped by the police for drunk driving. The participants were randomly drawn from a pool of over 600 protocols collected. Each driver was tested individually, in accordance with the standard procedure, by a certified transport psychologist (licence no. 14/2005).

The classification of the drivers into Groups 2-6 depended on their different degrees of involvement in road crashes. According to the NHTSA (2013), there are various classes of crashes – fatal (high class) and injury crashes (lower class). However, for the methodology of our analysis, we propose to treat drivers who have taken part in traffic conflicts without injuring people but causing material damages (which we call collisions) in a different way than those who have taken part in traffic conflicts with more serious consequences, where people were injured or even killed (in our paper, these are called accidents).

Victims and perpetrators of road collisions were selected during periodic examinations following referrals issued by their employers. Victims and perpetrators of traffic accidents and drivers stopped for drunk driving were sent for psychological examination by the police. Individuals suffering from postaccident trauma and those addicted to alcohol or other substances having similar effects were excluded from the study.

RESULTS

In order to answer the question of whether variables measuring a variety of drivers' predispositions are sufficiently correlated to make it possible to seek common factors, we computed the Kaiser-Meyer-Olkin test (.711), Bartlett's test (χ^2 = 2,446.26, *df* = 351, $p < .001$), and the determinant of the matrix (10^{-3}). The results of using them show that there is every reason to look for a higher order factor structure that will, on the one hand, explain the interrelations between the variables, and on the other – provide information about their redundancy in the measurements used in diagnostic practice in transport psychology in Poland. The ratio of the number of variables (27) to the number of cases (300) should also be regarded as fully satisfactory (1:11), that is, as guaranteeing the stability of factor structure in the examinaton of successive groups of participants drawn from a population with similar parameters.

Because it is important to explain as much variance in the original measurements as possible and at the same time to extract factors that will not result in information noise, the Kaiser criterion (eigenvalues equal to or higher than 1) was adopted as the criterion for the number of factors. The eigenvalues of the first 10 unrotated factors were: 5.01, 2.45, 1.92, 1.51, 1.46, 1.25, 1.12, 1.08, 0.97, 0.95, etc. The eight-factor solution was therefore found to be optimal. It explained 58.5% of the variance in the input data.

The maximum likelihood method was adopted as the method of factor extraction. Rotation was performed using the *Oblimin* method, allowing factor

correlation. The eight factors explained 44.3% of the variance: the lower percentage of variance compared to principal component analysis (58.54%) stems from the fact that in PCA all of the variance in the variable is included, whereas in factor analysis only the variance shared with other variables is to be accounted for.

The verification of the fit of the factor structure to the input data ($\chi^2 = 184.66$, $df = 163$, $p = .118$) indicates that the extracted factor structure satisfactorily explains the relations between variables in this data set. Table 2 contains detailed data concerning correlations between the variables analyzed and the extracted factor structure. The variables were sorted according to their loadings on particular factors.

Table 2
Factor Structure Matrix

Variable	Factor*							
	1	2	3	4	5	6	7	8
Poppelreuter: correctly written numbers	**.97**		-.11	.29	-.26	.42		
Poppelreuter: the longest series	**.86**	-.10	**-.62**	.33	-.31	.37	.10	
Dark Room Test: vision in the dark		**.99**	.11	-.12	.35	-.22	.11	
Dark Room Test: sensitivity to glare	-.16	**.73**	.17	-.12	.44	-.21		
Stereometer: Stereoscopic vision		**.25**	.15	-.03	.11	-.25	.13	
Kinesthesiometer Kinesthetic sensitivity		**-.20**					-.11	
Poppelreuter: number of mistakes	-.12		**.77**	-.13	.11	-.10	.05	-.11
NEO-FFI: Conscientiousness	.19		-.15	**.79**	-.05	.10	.40	.29
NEO-FFI: Neuroticism	-.16	.14	.19	**-.72**	.17	-.27	-.21	-.25
NEO-FFI: Agreeableness	.18		-.12	**.68**	-.12	.16	.18	.17
Piórkowski: Eye-hand coordination	.21	-.26	-.17	.21	**-.65**	.43	.10	.12
RTM: complex reaction time	-.17	.13	.12	-.13	**.59**	-.19		
RTM: mistakes of complex reaction	-.18	.15	.12		**.58**	-.19		-.11
RTM: distribution of simple reaction time	-.11		.18		**.51**		-.11	-.21
RTM: distribution of complex reaction time	-.15	.11	.10	-.10	**.50**		-.13	
RTM: simple reaction time		.24	.12		**.42**	-.18		
SPM D: permutations of figures	.26	-.17	-.13	.19	-.18	**.67**	.11	
SPM B: analogies between pairs of figures	.18	-.14	-.13	.21	-.15	**.63**	.13	.11
SPM C: progressive alterations of figures	.16	-.07	-.19	.19	-.17	**.60**	.19	
SPM E: resolution of figures	.23	-.16	-.12	.19	-.15	**.51**	.10	
SPM A: continuous patterns	.16			.11		**.44**		
NEO-FFI: Extraversion	.15			.45		.18	**.67**	.16
EPQ-R: Extraversion	.17	.11		.19	-.15	.22	**.52**	
NEO-FFI: Openness to Experience		.13		.12			**.48**	
EPQ-R: Social Desirability				.21				**.62**
EPQ-R: Neuroticism		.13	.25	-.28	.31	-.26	-.13	**-.52**
EPQ-R: Psychoticism			.13	-.16		-.19		**-.21**
Explained variance (%)	12.0	6.7	2.8	8.3	5.5	4.4	2.6	2.0

Note. * Factor loadings below .10 were omitted.

Data from Table 3 show that the absolute values of correlation coefficients between the factors do not exceed .30, which testifies to their weak or very weak intercorrelation and, consequently, to the relative independence of the extracted factors, representing eight groups of abilities or traits measured by transport psychologists in professional practice in Poland.

Table 3
Matrix of Correlations Between the Factors

Factor	1	2	3	4	5	6	7	8
1	1.00							
2	.01	1.00						
3	-.14	.13	1.00					
4	.20*	-.11	-.19*	1.00				
5	-.23*	.22*	.19*	-.11	1.00			
6	.23*	-.20*	-.20*	.25*	-.21*	1.00		
7	.13	.20*	.03	.29*	-.11	.09	1.00	
8	-.02	-.01	-.18*	.28*	-.09	.06	.09	1.00

Note. * $p < .01$

The first factor, explaining the largest percentage of variance (12.0%), measures drivers' ability to concentrate, divide, and alternate attention. The indicators that correlated with it most strongly were the total number of correctly written numbers (.97) and the longest series of correctly written numbers (.86) from the Poppelreuter test.

The second factor represents the measurement of drivers' visual perception accuracy: vision in the dark (.99) and sensitivity to glare (.73). Two other measurements of perception abilities are weakly correlated with this factor (though more strongly than with any other): stereoscopic vision (.25) and kinesthetic sensitivity (-.25).

The third factor is most strongly correlated with the number of mistakes made in series of numbers written (.77) and negatively with the longest series correctly written numbers (-.62) from the Poppelreuter test. At the theoretical level, this factor represents the ability of mental alertness to external signals. Such an ability correlates negatively with the number of mistakes made in series of numbers written in the Poppelreuter test, which is an indicator of this skill.

The fifth factor encompasses most measurements of drivers' psychomotor skills in the form of simple and complex reaction times and their distribution as

well as the eye–hand coordination indicator, negatively correlated with them. The negative correlation stems from the fact that individuals having better coordination exhibit shorter reaction times. Reaction speed is commonly regarded as an indicator of decision-making speed. Its interpretation is connected with skill in reacting and, consequently, also in making decisions.

The sixth factor groups all the sets of Raven's Standard Progressive Matrices (SPM): noticing permutations of figures (.67), noticing analogies between pairs of figures (.63), noticing progressive alterations of figures (.60), resolution of figures into constituent parts (.51), and noticing continuous patterns (.44). Thus, this factor represents the measurement of mental ability in the form of logical induction and noticing analogies. From the theoretical point of view, it corresponds to eductive ability as defined by Spearman (1927) and to the fluid intelligence factor as understood by Cattell (Horn & Cattell, 1966).

The fourth, seventh, and eighth factors measure personality traits and social desirability, making up clusters that are consistent in the psychological sense. The fourth factor is constituted by three NEO-FFI scales: Conscientiousness (.79), Neuroticism (-.72), and Agreeableness (.68). In terms of the dichotomy of social perception dimensions, they represent the Communion dimension (Abele, Uchronski, Suitner, & Wojciszke, 2008; Saucier, Thalmayer, Payne et al., 2014), which is of a higher order than the Big Five and pertains to the quality of an individual's social functioning.

The seventh factor corresponds, to some extent, to the second higher order dimension of social perception, referred to in the literature of the subject as Agency (Abele & Wojciszke, 2007). It is comprised of Extraversion as present in the NEO-FFI (.67) and in the EPQ-R (.52) as well as Openness to Experience (.48).

The last, eighth factor is constituted by the Deception (.62) and Neuroticism (-.52) scales from the EPQ-R questionnaire. Given the participants' high motivation to achieve positive results in the examination, all the self-report measurements are burdened with the social desirability bias. The factor under discussion measures this tendency, which, in the context of road traffic, can manifest itself in avoiding (high scores) vs. engaging in (low scores) socially undesirable behaviors, motivated by the need to leave other road users with a positive impression of oneself. It is worth noting that the remaining factors are not highly correlated with this factor to a cognitively valuable degree ($|r| < .20$), except for the weak correlation in the case of the fourth factor, Community (.28), which makes it legitimate to regard them as not burdened with the social desirability bias, unlike the original measurements.

It is also possible to pinpoint three of the 27 measurements included in the factor analysis that are explained to the smallest degree by the identified latent variables: kinesthetic sensitivity and movement precision (7% of explained variance), psychoticism (13%), and stereoscopic vision (17%).

CONCLUSION

The structure obtained in the present study is more extensive than that proposed by Markowski (2014), who believes that, of the skills and abilities necessary to drive vehicles safely, the ones that play the most important role are: information processing, attention, perception, making decisions under stress, and predicting events. Relating the results of the presented research to Łuczak's (2001) proposal, it should be stressed that the adopted direction of analyses is complementary to the deductive approach proposed by other researchers.

The approach proposed in the present article is an inductive one. We try to infer from the test batteries used by practitioners what factors are in fact measured. Cattell (1946) followed a similar approach when creating a method of exploring personality. This makes it possible to develop a new classification of skills and abilities important in qualifying tests for drivers.

Taking into account the models mentioned earlier, it is possible to try to determine a two-level structure organizing the extracted factors into three categories. The structure includes personality factors: community, agency, sensitivity to the social desirability bias; a group of skills-related factors: visual perception precision, reaction and decision-making skills; and factors characterizing the individual's abilities: the ability of concentrating, dividing, and alternating attention, mental alertness, and mental ability.

Unfortunately, the analyses performed have certain limitations, too. The main limitation is the pool of indicators. Although from the participants' point of view the number of tests and questionnaires is large, from the methodological point of view they do not represent the full range of tools available (cf. Łuczak & Najmiec, 2009). There is therefore a risk that if more tools are included the factor structure might undergo a certain modification. At the same time, even though the pool of 300 participants, with all the analyzed groups of drivers equal in size, is sufficient to perform analyses, expanding it would improve the reliability of the results.

In a longer-term perspective, there are plans to perform analyses that will determine the discriminatory and predictive value of the extracted factors. This in

turn will allow us to propose effective batteries of tests (using the best representatives of each factor, with the minimum number of measurements) after a verification of their validity.

The presented data make it possible to propose to a wide group of transport psychologists a basis for thoughtful selection of assessment tools so as to measure all the factors distinguished. A the same time, it opens the way to a reduction of the number of methods so as not to use multiple methods measuring the same factor.

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