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The Effect of Psychological Scarcity on Health Decisions of Rural Residents in China: Preliminary Results



Haiou Zhu, E. Liu, Fangzhou You, Cees de Bont, Thorsten Gruber, Hua Dong, and Marijke Melles

Abstract Economic studies have shown that living in poverty may produce a subjective feeling of scarcity, which affects people's cognitive functions and decision-making. Understanding this mechanism could inform healthcare designers on designing inclusive health interventions by considering the psychological scarcity and limited cognitive resources of impoverished individuals. We conducted a psychological experiment to test the impact of psychological scarcity on cognitive function and health decisions of rural residents in China. We randomly assign participants to two financial scenarios (hard vs. easy) with the technique of priming to induce their immediate financial worries. Then we measure cognitive function using Raven's Progressive Matrices and uncover their decision-making priorities with a budget allocation task. 301 participants finished the study and 264 were included in the main analysis. The results show that both immediate financial worries and cumulative poverty have negative effects on participants' cognitive performance. Responses to scarcity could lead to attentional focus on limited resources, thereby neglecting long-term health consequences, particularly for the lower income group. Based on the findings, we suggest a number of human factors design considerations that are critical to successful healthcare design.

Keywords Psychological scarcity · Cognitive function · Health decision-making · Health intervention

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1 Background

Suffering from illness is the greatest contributor to individual poverty in rural China (Liu et al. 2017). The lack of financial resources prevents people living in poverty from improving their health and quality of life, leading to a ‘poverty-disease’ trap they seem unable to escape (Sala-i-Martin 2005, p. 95). A growing body of research in economics investigates the psychological mechanism of poverty and its effects on individuals’ decision-making. Mani et al. (2013) define poverty as ‘the gap between one’s needs and the resources available to fulfill them’. Shafir and Mullainathan (2013, p. 4) highlight the subjective nature of scarcity, defining it as ‘having less than you feel you need’. The concept of psychological scarcity depicts that living in poverty itself may produce psychological consequences that lead to short-sighted (present bias) and risk-averse decision-making (Haushofer and Fehr 2014). This mechanism affects individuals’ health behaviours and decisions in lower-income settings, such as lower adherence, excessive alcohol consumption and lower adoption of health technology (Dupas and Miguel 2017).

In the field of ergonomics and human factors, the cognitive and psychological mechanisms of user decision-making are critical considerations for successful healthcare design (Lawler et al. 2011). Healthcare designers aiming to design inclusive healthcare could benefit from understanding how low-income individuals make decisions about their health. With the aid of a human factors approach to easing their psychological and cognitive strain, people in poverty may make better health decisions. However, there is a lack of research identifying the scarcity mechanism in design research. As a result, we conducted a psychological experiment to test the effect of psychological scarcity on health-related decisions of the rural population in China. Following previous studies (Carvalho et al. 2016; Mani et al. 2013), we used the technique of priming to induce participants’ financial worries and measure their immediate perceptions of scarcity. We then administered questionnaires aimed at eliciting their risk and time preferences. We used Raven’s matrix (Raven 2000) tasks to assess their cognitive function, followed by a hypothetical budget allocation to evaluate their decision-making priorities.

The purpose of this experiment is to understand the mechanism of psychological scarcity on health-related decisions and to discuss its implication for designing effective and human-centred health interventions in future research. The paper is structured as follows: we first introduce the design of experiment and the process of data collection and analysis. Then, we present the preliminary results of the study (the remaining results will be presented at a later stage). Next, we discuss the findings and their implications for design research. Based on the findings, we suggest a number of human factors design considerations that are critical to successful healthcare design in lower-income setting. Finally, we highlight limitations and provide directions for future research.

2 Methodology

2.1 Design of Experiment

This study uses an artefactual field experiment (Harrison and List 2004), which is a lab in the field approach, to collect data from rural China. We choose rural China because health disparities between rural and urban regions have been growing despite China's major progress in poverty alleviation (State Council 2015). The lack of financial resources, as well as healthcare infrastructures and services, are the primary obstacles for rural residents in seeking health and making better decisions about their quality of life. Healthcare designers might better design for, with and by these marginalised groups in Chinese society and promote inclusive and equitable healthcare (Fang and Xin 2018) by taking into account both macro level of economic and societal determinants and micro level of psychological mechanism.

The experiment was conducted between May and June 2022 in a town located in Yunnan Province, one of the least developed rural regions in southwestern China. The disposable income per capita in 2021 is ¥14,197 (€1,861) for rural residents, compared to ¥40,905 (€5,361) for urban residents in this province. The town has eight communities and 85 natural villages, with a population of 31,117 people, of whom about 94.8% live in rural areas. The ethnic minorities make up 21.2% of the population. The study was approved by the ethics committee of Loughborough University. A pilot study was conducted to refine the experiment design and to adapt materials and measurements to local contexts. To be eligible for the study, participants needed to be: (i) 18 years old above (ii) living in rural areas (iii) able to comprehend the instruction and perform the tasks accordingly.

The experiment consisted of two treatments, the 'hard' financial scenarios and the 'easy' financial scenarios, which were referred to as the treatment and placebo groups. The method of priming, frequently used in psychology and economics (Cohn and Maréchal 2016), was adopted to induce participants to think about financial circumstances that they might encounter in daily life. Participants were asked how they would handle three different sets of financial shocks: raising money in one week, declining of annual income and increasing of medical costs. The first two sets were adapted from Mani et al. (2013), whereas the third set was primarily about financial shocks brought on by illness. The descriptions and questions are identical in all sets of scenarios for the two groups except that the magnitude of money varies. For example, the 'hard' scenario describes an unforeseen event requiring an immediate ¥20,000 expense, whereas the 'easy' scenario only requires ¥1000 expense. The participants were exposed to each of the three scenarios and were asked to respond both open-ended and closed-ended questions. The open-ended questions asked participants to respond in three sentences on how they would handle the financial shocks to trigger feelings and concerns. The closed-ended questions were coded with five-item Likert scales to measure the levels of worries. Responses to these scales were used to check if the manipulation was successful in inducing increased levels of worries in

the treatment group. The detailed descriptions and all questions for the priming of financial scenarios can be seen in Appendix 1.

The primary variables include cognitive function, risk preference (monetary and health), time preference (monetary and health), and decision-making measurements. In this paper, we only introduce the methods to measure cognitive function and decision-making.

For the measurement of cognitive function, Raven's Progressive Matrices (Raven 2000) were used, with which participants try to match a set of graphic patterns (see an example in Appendix 2). It is one of the most prominent and widely used tools in psychology and economics for measuring fluid intelligence, a core feature of individuals' cognitive capacity to think logically and solve problems in novel situations (Schilbach et al. 2016). Given that our participants have very low levels of literacy (18.56% illiterate), a non-verbal test is more appropriate to administer in the field.

For the measurement of purchase decisions, participants were asked to allocate a hypothetical budget of ¥100 over three categories of goods: (i) daily groceries (ii) medicine and health-related goods (iii) temptation goods. The items selected are popular and well-known in local market and were refined after the pilot study. These product categories represent decision-making priorities of participants: health goods are catered to a long-term priority on health; groceries satisfy immediate family needs while temptation goods cater to short-term utility.

2.2 Data Collection and Analysis

The authors provided training for locally hired research assistants to collect data in the field. The survey questions and research materials were adjusted for the local dialect and culture to ease the participants' burden on answering questions. The research assistants, who are familiar with local environments, travelled to the villages and the weekend market in the town. They approached residents and introduced the study to them. After acquiring their informed consent, participants were randomly assigned to the two financial scenarios to answer the priming questions. When answering the open-ended questions, they were given adequate time to process the information, and were encouraged to imagine and describe what kind of impacts these financial shocks could have in their own lives and how they would handle them. Then they were instructed to answer questions for risk and time preference elicitation, perform the budget allocation task, complete the Raven's Matrices task, and answer demographic questions. After the experiment, participants received a towel (€0.3 worth) as a 'thankyou' gift.

A sample of 301 participants finished the experiment, of which 150 were randomly assigned to the hard scenarios and 151 to the easy scenarios. We used the IBM SPSS Statistics 28 for data analysis. Of the participants, 37 were excluded (20 from hard scenarios and 17 from easy scenarios) as they contain outliers ($Z > 2$ & $Z < -2$) in their annual income, household income or budget allocation amount. The final

sample included in the main analysis is 264, of which 130 were from the group of hard scenarios and 134 from the group of easy scenarios.

Table 1 provides a summary of the participant's demographics, including gender, age, education, and source of income. Males account for 54.26% of the population, while females account for 45.74%. The majority of the participants (76.24%) fall into the 41–50, 51–60 and 60–plus age brackets. This is consistent with the current situation of Chinese society where the older generation stays at home while young adults leave home to study or work in the city. 18.56% of the participants are illiterate and 38.26% only go to primary school. According to the results of the source of income, migrant employment (31.56%) and farming (15.96%) account for roughly half of the participants' income. 13.48% of the participants rely on family support and 3.19% have no income. Those who do not have a source of income would be given government sustenance payments according to the feedback from the research assistants. The mean of annual income is ¥28,462.48 (€3730.34), and the median is ¥20,000 (€2621).

Table 1 Participant demographics

Sample characteristics		Number	Percentage (%)
Gender	Male	140	53.03
	Female	124	46.97
Age	18–30	25	9.47
	31–40	38	14.39
	41–50	59	22.35
	51–60	55	20.83
	60 years above	87	32.95
Education	Illiterate	49	18.56
	Primary school	101	38.26
	Middle school	52	19.70
	High school	31	11.74
	Undergraduate and above	31	11.74
Income sources	Migrant working	84	31.82
	Farming	45	17.05
	Family support	36	13.64
	No income	8	3.03
	Other	91	34.47

3 Results

This section presents balance check for randomisation, manipulation check and treatment effects on cognitive function and decision-making.

3.1 Balance Check

Table 2 shows balance check results, by comparing the characteristics of participants in the ‘hard’ and ‘easy’ scenarios. The last column displays the p-value of the t-Test for the two treatment groups. These tests reveal no significant differences between the two groups, indicating that the randomization resulted in a balanced trial group.

3.2 Manipulation Check

The purpose of the manipulation check is to confirm that the priming succeeded in triggering financial worries for the ‘hard’ scenario group. The responses to the open-ended questions offer qualitative evidence that the scenarios were thought to be challenging. The answers to the closed-ended (yes or no) questions and the Likert scales provide data to quantify the effects of these financial scenarios. Figure 1 presents the response means of the three financial scenarios, which show a clear increase of subjective perceptions of worries and/or difficulties for participants exposed to ‘hard’ scenarios relative to ‘easy’ scenarios. According to the results of multivariate regressions (see Appendix 1), the joint p-value is significant at the 1% level ($p < 0.001$), suggesting that the experimental manipulation was successful in inducing immediate financial worries.

3.3 Treatment Effects

Poverty may impede cognitive function directly (Mani et al. 2013). We measured cognitive functioning using the Raven’s matrix. To investigate whether cognitive function would be affected by immediate monetary concerns or long-term economic conditions, we compare the differences of correct rate between ‘hard’ and ‘easy’ groups, as well as between lower income and higher income split by median annual income (¥20,000). The average correct rate of ‘hard’ group (54.60%) is lower than the ‘easy’ group (61.54%), with a mean difference significant at 0.1 level (two-sample t test, two-tailed test: $t = 1.875$, $p = 0.062^*$). Individuals with lower incomes (43.02%) performed significantly worse than those with higher incomes (71.10%), with a correct rate fall of 28.08% (two-sample t test, two-tailed test: $t = -8.498$,

Table 2 Balance check

Sample characteristics	Full sample		Means by treatments				Hard-easy Differences in means (p value)
	Mean	SD	Hard scenario		Easy scenario		
	N = 264		n = 130		n = 134		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gender	1.47	0.500	1.43	0.497	1.51	0.502	0.225
Age	5.49	1.430	5.51	1.347	5.46	1.516	0.762
Education	2.60	1.248	2.67	1.206	2.52	1.289	0.334
Income sources	2.91	1.690	2.88	1.773	2.95	1.606	0.753
Annual income	28,462.48	28,868.232	31,308.97	29,205.851	25,528.40	28,328.927	0.104

Notes: Columns (1)–(2) show the means and standard deviation of the full sample. Columns (3)–(6) show the means and standard deviation across treatment arms. Column (7) displays the p-values of differences in means tests using t-tests. * p < 0.10, ** p < 0.05, *** p < 0.01

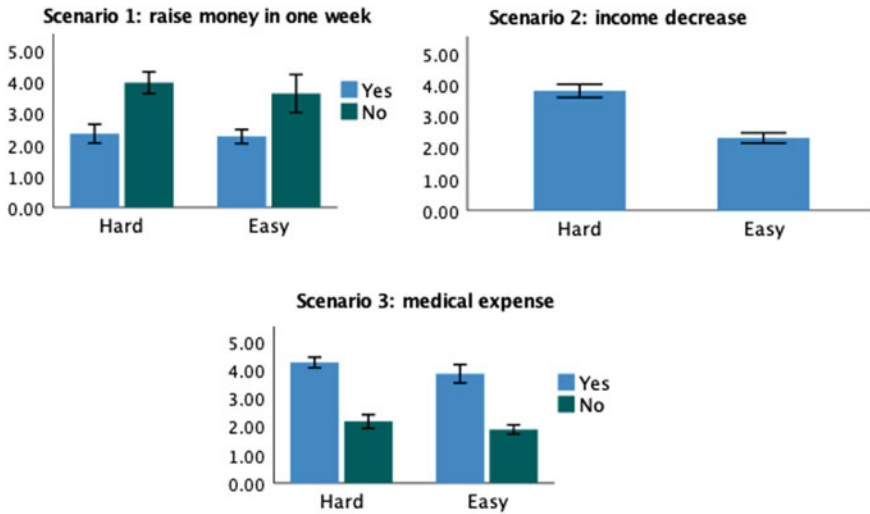


Fig. 1 Impact of Hard versus Easy Scenarios on Financial Worries. *Notes* The bars show hard-easy mean differences for the three financial scenarios: raise money in one week, income decrease and medical expense. Brackets indicate 95% confidence intervals. Scenarios 1 and scenario 3 are split by asking participants ‘Are there ways in which you may be able to raise the money in one week?’; and ‘Would it be difficult to afford healthcare?’

$p < 0.001^{***}$). Furthermore, within the sample of lower incomes, the correct rate of participants exposed to hard scenarios (34.57%) is lower than that of participants exposed to easy scenarios (49.64%) and the mean difference is significant at 0.05 level (two-sample t test, two-tailed test: $t = 3.156$, $p = 0.002^{**}$). While within the sample of higher incomes, there is no significance (two-sample t test, two-tailed test: $t = 1.541$, $p = 0.126$). The above findings suggest that both immediate financial worries and long-term poverty conditions have an impact on cognitive performance. People with lower income would be affected by both subjective feeling of scarcity and absolute level of resource scarcity, whereas those with higher income appear unaffected by the immediate worries (Fig. 2).

To identify the impact of financial worries on the demand for the three types of household goods (groceries, health and temptation), we designed a budget allocation task (with a budget of ¥100) to measure participants’ trade-off thinking and decision-making. Table 3 presents regression results, separately for the ‘hard’ and ‘easy’ scenarios and for the lower income and higher income groups. The findings show that compared to the ‘easy’ group, the ‘hard’ group spent less on groceries and temptation items, but the differences are not significant. The ‘hard’ group spent more on health and the difference is significant at 0.1 level ($p = 0.064$). What is remarkable is between the lower income group and the higher income group. The lower income group spent 21.68% more on health but 63.14% less on temptation goods than the higher income group did, and the differences are significant at 0.05 level ($p = 0.015$) and 0.01 level ($p < 0.001$) respectively. It seems that those with

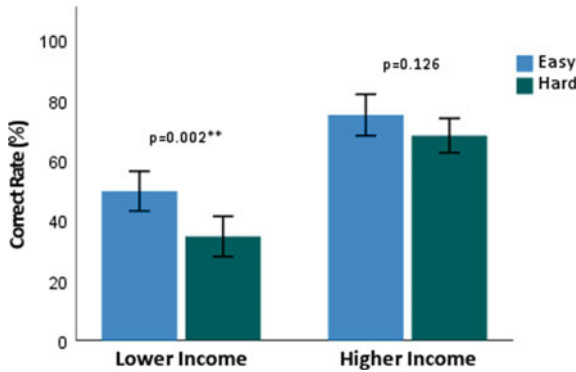


Fig. 2 Correct rate of Raven’s matrix. *Notes* The bars indicate the correct rate, and the brackets indicate 95% confidence intervals. Easy (n = 130) and Hard (n = 134) indicates mean correct rate of individuals assigned to easy/hard financial scenarios respectively. Lower income (n = 123) and higher income (n = 141) indicate mean correct rate of individuals split by median annual income (¥20,000). P-values above the bars show statistical significance between ‘hard’ and ‘easy’ scenarios or within the lower income group and higher income group. *p < 0.10, **p < 0.05, ***p < 0.01

lower income behave more consistent with rationality, allocating their limited budget more on long term investment such as health rather than impulsive items they might not necessarily need.

4 Discussion

From an ergonomics and human factors perspective, two parts of our findings have direct implications for healthcare design. The first reveals that financial concerns adversely affect participants’ cognitive performance, particularly among those with lower incomes (in our sample, individuals earning less than \$20,000 annually). This is in line with prior studies (Lichand and Mani 2020; Mani et al. 2013; Ong et al. 2019) that observed worse cognitive performance in financially strained groups.

The field of cognitive ergonomics concerns ‘mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system’ (IEA 2022). Our results showcase cognitive limitations in impoverished individuals, which is one of the most critical human factors design considerations. Recognising poverty as the underlying attribute to cognitive function could enrich healthcare designers’ understanding of such user group. As an illustration, people living in developing areas may have difficulties in adopting new technologies (Dupas and Miguel 2017). Consider two possible healthcare interventions to improve the adoption of a new digital health information technology. A design that considers users’ cognitive load would simplify information structure of the digital health system to alleviate cognitive demands of using the new technology.

Table 3 Purchase decisions on groceries, health goods and temptation goods

	Proportion of money allocated (%)		
	Groceries	Health	Temptation
Hard versus Easy			
{Easy scenario}	1.91 (2.648)	-4.69 (2.521)*	2.78 (2.051)
Constant	57.73 (1.858)	33.44 (1.769)	8.83 (1.439)
Lower income versus Higher income			
{Higher income}	-3.00 (2.650)	-6.13 (2.515)**	9.13 (1.984)***
Constant	60.27 (1.937)	34.41 (1.838)	5.33 (1.450)
Observations	264	264	264

Notes The dependent variables are the proportion of money allocated to each of the three categories of goods (groceries, health and temptation). The first panel reports results from general linear regression of proportion of money on the 'easy scenario' indicator variable and a constant. The second panel reports results from general linear regression of proportion of money on the 'higher income' indicator variable and a constant. The coefficient on the constant shows the mean for the 'hard' group and the lower income group respectively. Standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

But a design ignores daily life taxing on cognitive capability might design complex versions.

The second finding is that poverty affects decision making both psychologically and financially. In economics study, there are two opposing perspectives on the consequences of scarcity: one is that it could lead to decision-making errors and counter-productive behaviour (Mani et al. 2013), and the other is that it produces a tunnelling effect and draws attentional focus to the task at hand (Zhao and Tamm 2018). Our results appear to support the latter. Participants assigned to 'hard' scenarios experienced greater levels of immediate monetary concerns and spent more on health goods. The effect is more significant when comparing higher income and lower income groups for their choices of health and temptation goods. The lower income spent much more on health goods and much less on temptation goods. A possible explanation is that participants with lower income detect the health-related cues in the task and perform better when making trade-off on limited budgetary resources.

Healthcare designers could greatly benefit from understanding this psychological scarcity mechanism and the trade-off thinking in people's decision-making process when designing potential health interventions. Our research implies that a more successful intervention would involve providing appropriate cues to direct attentional focus as well as guidance for decisions and actions. For instance, health promotion campaigns, like those for getting vaccination and quitting smoking, should place more emphasis on information related to scarcity and offer salient cues to capture

attention. A minor alteration to the user interface or to the feature of a designed object may have a significant impact on individuals' decisions and behaviours.

In addition to the practical human factors design considerations, the study may also shed light on novel approaches to designing inclusive and equitable healthcare targeting these user groups at the systemic and policy level, which would necessitate knowledge of systematic design and policy design. Policies aiming at enhancing the health and quality of life of the poor should consider both the objective and subjective aspects of scarcity to lessen both financial burden and psychological and cognitive load. According to the "World Development Report" (World Bank 2015), there are three promising ways to ensure that poor people have adequate cognitive space to make the best decisions: simplify procedures; target assistance based on cognitive bandwidth; and continue anti-poverty initiatives to reduce income volatility and improve infrastructure. Future studies could look into how design research and practice, with a holistic design approach, could contribute to these solutions and improve the health of impoverished individuals who are struggling in the 'poverty-disease' trap.

To balance the cost and ease of collecting data in the field, we used a relatively simple method to measure the cognitive function. Future research could employ various techniques and improve accuracy. In our upcoming study, we aim at designing tailored health interventions considering the impact of both objective and subjective scarcity and examining their feasibility and effectiveness.

5 Conclusions

In this study, we introduced the concept of psychological scarcity from economics into design research. We presented results from a lab in the field experiment in rural China designed to induce scarcity and examine the impact of financial worries on cognitive function and health-related decisions. Our findings suggest that cognitive performance is negatively impacted by financial worries and that the impact of poverty on decision making is both psychological and financial. It could facilitate academics and practitioners in healthcare design to comprehend the scarcity mechanism and how impoverished individuals make decisions about their health. Furthermore, it has a potential to expand to more contexts and pressing issues that could produce scarcity mindset, such as covid-19 quarantine and refugee aid.

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Appendix 1

See Table 4.

Table 4 Manipulation check

Dependent variable			
N = 264	Mean for		
	Hard scenario	{Easy scenario}	
		Coefficient	P-value
<i>Scenario 1 Raise money in one week</i>			
Imagine that an unforeseen event requires of you an immediate (¥20,000/¥1000) expense. You need to raise the money in less than a week			
Are there ways in which you may be able to raise the money in one week?	1.43	-0.27	<0.001***
To what extent do you agree with the following statements:	2.99	-0.52	0.007**
(a) 'Coming up with (¥20,000/¥1000) on a very short notice would cause me long-lasting financial hardship.'			
(b) 'Coming up with (¥20,000/¥1000) on a very short notice would require me to make sacrifices that have long-term consequences.'	3.24	-0.72	<0.001***
<i>Scenario 2 Income decrease shock</i>			
Imagine that the economy is going through difficult times. The income in your family decreases by (50%/5%). To what extent do you agree with the following statements:			
(a) 'Given my situation, I would be able to maintain roughly the same lifestyle under those new circumstances.'	2.11	1.51	<0.001***
(b) 'The (50%/5%) decrease in our income would strongly impact our daily life.'	3.95	-1.64	<0.001***
<i>Scenario 3 Healthcare increase shock</i>			
Imaging that due to serve illness, there is an increase in the monthly cost of healthcare by (¥2000/¥100) for your family, which amounts to a total cost increase of (¥24,000/¥1200) a year. This increase is not reimbursable by any government funding scheme			
Would it be difficult to afford healthcare?	1.32	0.44	<0.001***
To what extent do you agree with the following statements:	3.87	-1.42	<0.001***
(a) 'Paying additional (¥2000/¥100) a month for healthcare would require difficult budget cuts and sacrifices every month.'			
(b) 'Paying additional (¥2000/¥100) a month for healthcare would be too costly and it would probably result in forgoing going to the hospital	3.46	-1.09	<0.001***
Joint test			<0.001***

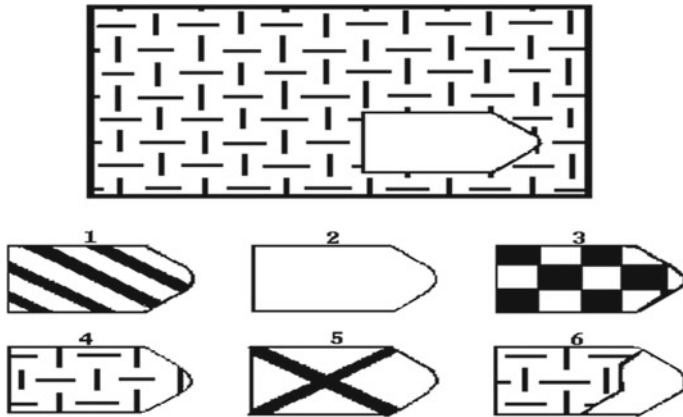


Fig. 3 Example of Raven's progressive matrices

Appendix 2

See Fig. 3.

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