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EFFECTS OF INTELLIGENCE AND MEMORY ON NEUROPSYCHOLOGICAL RESPONSES IN POLYGRAPH TESTING

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Abstract: The polygraph is widely used to detect concealed information or deception; however, whether examinees' intelligence and memory quotients would influence the psychophysiological responses, and thus the effectiveness of the polygraph, has rarely been studied systematically. The present study investigated this issue by using a polygraph on 82 participants with intelligence or memory impairments in a Concealed Information Test (CIT). The Wechsler Adult Intelligence Scale and the Wechsler Memory Scale were used to measure participants' intelligence and memory quotients. Analysis showed that participants' total IQ score and their scores on subtests, including information, comprehension, similarities, arithmetic, digit-symbol coding, and block design, were positively correlated with skin conductance response and the detect accuracy of the polygraph test. Participants who were tested inaccurately had significantly lower IQ scores than those who were tested accurately. In contrast, no significant correlation was found between MQ and polygraph test accuracy; however, further research is needed to investigate this issue, considering the floor effect of the Wechsler Memory Scale. The present study is not only beneficial for utilizing polygraph more scientifically, but also for expanding its application on people with cognitive impairments.

Key words: Polygraph, neuropsychological responses, electrodermal activity, intelligence, memory.

INTRODUCTION

The polygraph is an instrument that measures and records physiological responses such as skin conductance, respiration, finger pulse, and blood pressure. By analyzing these physiological responses to specific stimuli, we can infer an individual's psychological activities, such as cognition, emotion, deception, or conceal information in memory(Ben-Shakhar, 2012). Usually, the polygraph test requires that the examinee has normal mental status, as an abnormal mental status may influence the test's accuracy (Patrick & Iacono, 1989; Verschuere, Crombez, De Clercq, & Koster, 2005). For this reason, the polygraph is rarely used on people with mental problems, such as intelligence or memory defects, which has hampered its utilization in the field of forensic psychiatry(Grubin, 2010). However, whether intelligence or memory ability actually does influence the accuracy of the polygraph test still lacks fundamental and quantitative evidence currently. In 2003, the American National Research Council conducted a nationwide investigation to review the scientific evidence on the polygraph test(Council, 2003). The Council found little research regarding the effects of individual psychophysiological differences on the accuracy of the polygraph test, and concluded that research on the effects of examinees' physical and psychological condition on the polygraph test was extremely limited in this field. They indicated that this kind of research was only just beginning, and that little was known about what impacts intelligence and memory have on polygraph testing. From an applied perspective, it is of great importance to know the moderating role of intelligence and memory ability on the detection accuracy of the polygraph test. In order to address this question systematically and quantitatively, the present study utilized the polygraph for lie detection on people with intelligence or memory defects based on a Concealed Information Test (CIT).

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METHODS

Participants

Eighty-eight patients (70 males and 18 females) referred for neuropsychological assessment with complaints of intelligence or memory defects were enrolled to participate in this study. Data for four males and two females were excluded due to excessive motion during the polygraph test. This left 82 participants (66 males and 16 females) with a mean age of 44.70 years (SD = 13.03) and educational level of 7.80 years (SD = 3.15). Prior to the polygraph study, all of the 82 participants completed the IQ test, while only 49 completed the MQ test (40 males and 9 females) with a mean age of 42.80 years (SD = 12.50) and educational level of 7.92 years (SD = 3.08). Participants who completed the study successfully received a booklet introducing knowledge and methods for improving intelligence and memory ability (Table 1).

Instruments

The Wechsler Adult Intelligence Scale (WAIS) and the Wechsler Memory Scale (WMS) were used to assess the IQ and MQ of participants. The polygraph lux-4 (YCTECH CO., Ltd., Institute of Automation, Chinese Academy of Sciences) was used to measure and record skin conductance, respiration, and finger pulse in this study.

Procedure

This study was approved by the Medical Ethics Committee of Sichuan University. All participants signed a letter of informed consent before participating. After completing the IQ and MQ tests, participants were asked to select one of five cards on which a single number (4, 5, 6, 7, or 8) was printed. They were asked to memorize the selected number and write it down without being observed by the experimenter. The selected number was defined as the relevant item, and the other numbers were defined as irrelevant items. Participants were informed that they were going to take part in a lie detection experiment and they were asked to try to beat the polygraph by hiding recognition of the number they selected.

In the test, the participants were verbally asked the question, "Did you select the number X?" and were instructed to answer "No" to each question. The test consisted of three consecutive blocks of five numbers. The first block started with two buffer items, numbers 2 and 9, followed by 4, 5, 6, 7, and 8 with an inter-stimulus interval of 15 to 30 s. The five numbers would be presented at a fixed pseudorandom position in the second and third block. At the end of the experiment, participants were asked to state the number that they had memorized.

Response scoring

The skin conductance response (SCR) was computed as the maximal increase in skin conductance, from 0.5 s after the stimulus onset to 5 s after the stimulus offset. Finger pulse wave length (FPWL) starting from 0.5 s after stimulus onset up to three pulse cycles following the stimulus offset was recorded, where shorter lines correspond to stronger responses. Respiration line length (RLL) starting from 0.5 s after stimulus onset up to one respiratory cycle following stimulus offset was measured, where shorter lines correspond to stronger responses. If physiological responses to the selected number were greater than to other numbers, the test would be regarded as accurate.

RESULTS

Recall task of the selected number

Following polygraph testing, 71 participants correctly recalled the number they had selected, while one participant remembered the number incorrectly. Eight participants forgot the number they had selected and two were not sure which one they had selected between two numbers.

Accuracy rate of the polygraph test

The SCR of participants was the most useful index, with an accuracy rate of 70.7%. Both respiration and finger pulse had low accuracy rates, which were 37.8% and 46.3%, respectively. No correlation was found between responses of skin conductance, respiration, and finger pulse. Combination of the three indices did not improve the accuracy as compared to only using skin conductance (Table 2).

Table 1. Demographic information of participants

Test	Number (Total/Male)	Age		Educational Level (years)	
		$\bar{\chi}$	*s*	$\bar{\chi}$	*s*
Polygraph	82/66	44.70	13.03	7.80	3.15
IQ test	82/66	44.70	13.03	7.80	3.15
MQ test	49/40	42.80	12.50	7.92	3.08

Table 2. Accuracy rate of the polygraph test

Index	Accurate Rate	Inaccurate Rate
SCR	70.7% (58/82)	29.3%(24/82)
Respiration	37.8% (31/82)	62.2%(51/82)
Finger Pulse	46.3%(38/82)	53.7%(44/82)
Combination	67.1% (55/82)	32.9% (27/82)

Correlation between IQ and polygraph test accuracy

An independent samples t-test was conducted to compare IQ scores between the accurate group and the inaccurate group, and correlation analysis was conducted to measure the correlation between IQ and polygraph test accuracy. Results are shown in Table 3 and Figure 1.

As can be seen in Table 3, age did not differ significantly between the two groups (t = -1.62, P = 0.11), and no significant correlation was found between age and accuracy of the test. However, educational level did significantly correlate with the accuracy of the polygraph test. Participants who were tested accurately had significantly higher education levels than those tested inaccurately (t = 2.15, P = 0.03).

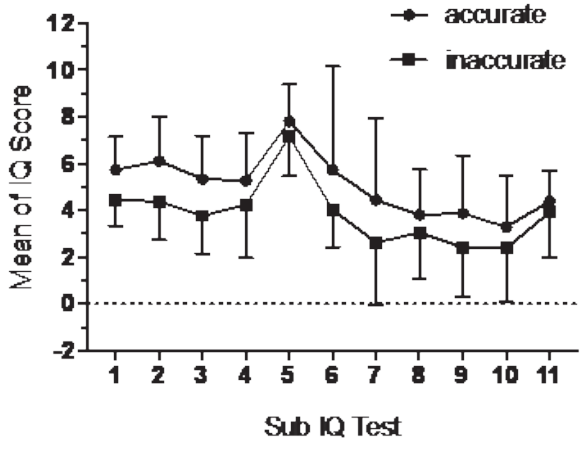

Figure 1. Comparison of subsets IQ score between accurate and inaccurate group.

The mean IQ of the accurate group was significantly higher than that of the inaccurate group (t = 2.05, P = 0.01). In line with this, scores on subtests, including information, comprehension, arithmetic, similarities, digit-symbol coding, and block design in the accurate group were significantly higher than those in the inaccurate group. The effect size was large for information, comprehension, and arithmetic (Cohen's d = 0.97, 0.97, and 0.90, respectively). Furthermore, scores of the aforementioned indices were correlated with the accuracy of the polygraph test. By contrast, although the scores of digit span, vocabulary, picture completion, picture arrangement, and object assembly were higher in the accurate group than those in the inaccurate group, the difference did not reach statistical significance (all P >0.05).

Correlation between IQ and physiological responses

Linear correlation analysis was conducted to see whether there is an association between IQ and physiological responses. Results showed that IQ score correlated only with SCR, and not respiration or finger pulse. The average SCR to the five numbers was positively correlated with the scores of digit-symbol coding and block design, while SCR to the relevant number was positively correlated with total IQ and subtest scores, including comprehension, arithmetic, vocabulary, digit-symbol coding, block design, and picture arrangement. Scores of aforementioned IQ

Table 3. Difference of IQ between accurate and inaccurate group; correlation between IQ and the accuracy of polygraph test

	Accurate (*n*=56)		Inaccurate (*n*=26)		*Cohen's d*	*t*	*P*	*Correlation*	
	$\bar{\chi}$	*s*	$\bar{\chi}$	*s*				*r*	*P*
Age	43.13	13.71	48.08	10.93	-0.41	-1.62	.11	-.17	.12
Education	8.30	3.15	6.73	2.92	0.52	2.15	.03	.25	.02
FSIQ	65.30	11.04	58.73	10.47	0.61	2.55	.01	.29	.01
Information	5.73	1.42	4.46	1.14	0.97	4.00	.01	.42	.01
Comprehension	6.11	1.90	4.38	1.65	0.97	3.97	.01	.42	.01
Arithmetic	5.34	1.84	3.77	1.63	0.90	3.72	.01	.37	.01
Similarities	5.27	2.03	4.23	2.27	0.48	2.07	.04	.24	.03
Digit span	7.80	1.58	7.15	1.67	0.40	1.71	.09	.18	.11
Vocabulary	5.73	4.41	4.04	1.61	0.51	1.90	.06	.33	.01
Coding	4.45	3.46	2.62	2.64	0.59	2.39	.02	.25	.02
Pic. completion	3.82	1.93	3.04	1.95	0.40	1.71	.09	.17	.12
Block design	3.88	2.48	2.42	2.12	0.63	2.58	.01	.28	.01
Pic. arrangement	3.29	2.21	2.38	2.26	0.41	1.71	.09	.18	.12
Assembly	4.39	1.32	3.92	1.94	0.28	1.12	.27	.18	.11

Pic. = Picture.

Table 4. Correlation between IQ and physiological responses in the polygraph test

Index		FS IQ	INF	COM	ARI	SIM	DIG	VOC	COD	PC	BLO	PA	ASS
M of SCR	*r*	.18	.05	.12	.15	.13	.07	.13	.23	.19	.27	.22	.18
	p	.12	.64	.27	.17	.26	.53	.25	.04	.10	.01	.05	.12
SCR-R	*r*	.23	.22	.25	.26	.19	.10	.26	.30	.17	.36	.30	.18
	p	.04	.05	.03	.02	.08	.36	.02	.01	.12	.01	.01	.11
M of SCR-N	*r*	.11	.03	.04	.07	.06	.04	.04	.14	.15	.16	.12	.13
	p	.33	.75	.75	.55	.58	.73	.75	.22	.19	.15	.27	.24
ΔSCR	*r*	.17	.24	.23	.23	.16	.08	.25	.23	.10	.28	.24	.11
	p	.13	.03	.04	.04	.15	.46	.03	.04	.39	.01	.04	.33

Note. M of SCR = mean of skin conductance response to all numbers; SCR-R = skin conductance response to relevant number; M of SCR-N = mean of skin conductance responses to neutral numbers; ΔSCR = difference between skin conductance to relevant and neutral number; FSIQ = full scale intelligence quotient; INF = information; COM = comprehension; ARI = arithmetic; SIM = similarity; DIG = digit span; VOC = vocabulary; COD = digit symbol coding; PC =picture completion; BLO = block design; PA = picture arrangement; ASS = picture assembly

indices as well as information score were also positively correlated with the difference of SCR between the relevant number and irrelevant numbers. Results are presented in Table 4.

Difference of MQ between accurate and inaccurate group

Of the 49 participants who finished the MQ test, 12 scored an MQ greater than 51(M = 63.75, SD = 9.35), while the other 37 scored less than 51 without detailed quotient. Age and education year did not differ significantly ($P > 0.05$) between accurate and inaccurate groups. Independent samples t-test showed that the scores on all MQ subtests in the accurate group were higher than those in the inaccurate group, but the differences did not reach the level of significance (all $P > 0.05$).

DISCUSSION

To the best of our knowledge, the present study is the first to quantitatively investigate the effects of IQ and MQ on psychophysiological response to concealed information in polygraph testing. In general, IQ impairments diminish SCR to relevant items and decrease the accuracy of the polygraph test. However, in contrast to our expectations, no significant correlation was found between MQ (as measured by WMS) and physiological response or polygraph test accuracy; however, this result should be interpreted with caution because of the floor effect of the WMS.

WAIS IQ showed a positive impact on SCR in the polygraph test, which is consistent with pretest expectations. Participants with higher IQ showed greater SCR to relevant items and greater disparity between relevant and irrelevant responses. As a result, people with higher IQ were better detected than those with lower IQ. A more focused inspection of the results revealed that scores of IQ subtests, including information, comprehension, arithmetic, similarities, digit-symbol coding, and block design contribute to the impact of IQ on SCR and test accuracy. These sub-indices of IQ represent abilities such as verbal comprehension, working memory, processing speed, and perceptual reasoning, which are related to psychological processes of memory and cognitive arousal in lying(Gass & Gutierrez, 2017). People with lower IQ might have difficulties concentrating on the test and may integrate their cognitive resources to conceal the information, thus having quite low physiological responses when lying. In contrast, people with higher IQ could comprehensively understand the purpose and procedures of the test and utilize more neuropsychological resources to conceal relevant information, which would then induce larger responses to relevant items and result in better detection. These results indicated that the lying-related abilities of test comprehension and concentration are important factors in the detection efficiency of the polygraph test. The examiner should fully communicate with examinees prior to the test to make sure they are motivated and totally concentrated on the test.

Attention was an important concern during polygraph testing. Disrupted attention would attenuate the response to relevant items, thereby degrading test accuracy(Waid, Orne, Cook, & Orne, 1978). In the IQ subtests, digit span is usually used to index the abilities of attention and short-term memory. However, the present study detected no significant correlation between digit span score and SCR. Digit span scores in both the accurate and inaccurate groups were at the normal level, and no significant difference was found between the two groups. This is possibly because the digit span test in WAIS is too easy to index the level

of attention ability that is essential for the polygraph test. Future study could utilize other instruments which are more effective to index attention ability, so as to investigate the effect of attention on the accuracy of polygraph testing.

Memory arousal is a central psychological basis of CIT (Veschuere, Ben-Sharkhar, & Meijer, 2011). However, to our surprise, although the memory scores on all WMS subtests in the inaccurate group were lower than those in the accurate group, the difference did not reach significance in the present study. Furthermore, the difference was not significant when the MQ scores were divided into immediate, short-term, and long-term memory subsets. Two aspects might account for this result. One is that the discrimination validity of the WMS may be insufficient to index memory ability for participants in the present study. As we know, the lowest score of WMS is 51, but most of the participants' MQs (37/49) were less than 51, without detailed scoring under 51. In this situation, we could not distinguish memory ability in detail between participants, and thereby could not analyze the association between the total MQ and the accuracy of the polygraph test. The other interpretation of this result might be that the extent of memory impairment of the participants did not influence the accuracy of the polygraph test. The paradigm used in the present study required participants to memorize the number they had selected, which was an easy task requiring very little memorial resources, and most of the participants could complete it successfully. In future study, a more complex paradigm and a more effective memory scale should be used to investigate the effect of memory on the accuracy of the polygraph test.

In the recall task at the end of the test, eight participants stated that they had forgotten which number they had selected. Among the eight participants, half of them were tested inaccurately. This result may indicate that these four participants had severe short-term memory impairment and that no special psychological responses were induced because of the absence of memory. In contrast, the other four participants stated that they had forgotten the selected number, but the polygraph correctly detected the number they had written on the paper. These results indicate that the polygraph has the potential to identify memory or "true experience" in the mind even when the individual could not clearly memorize the information. This is possibly because these four participants may have kept the selected number in their mind, but could not recall and recognize it due to impairment in memory retrieval ability. This interpretation is consistent with the theory that memory impairment in patients with traumatic brain injury (TBI) only involves the explicit memory (active recall and recognition), while implicit memory is retained(Vakil, 2005). Previous studies have reported that psychophysiological measures are sensitive to content of implicit memory (Haan, Bauer, & Greve, 1992; Roediger, 1990; Verfaellie, Bauer, & Bowers, 1991). In other words, information unavailable for conscious recollection may be activated on a psychophysiological level. However, because only two samples were involved in this analysis, further study is necessary to examine this potential. Apart from the aforementioned problem, there was one participant who reported that the number he had selected was five, but actually the number he wrote down on the paper was four. The polygraph identified five as the relevant number. This result indicates that the polygraph test might be more sensitive in identifying subjective memory content than to objective truth. Again, for the reason of small sample size, this question merits further investigation.

In conclusion, IQ impairments can diminish skin conductance response and decrease the accuracy of polygraph testing. Thoroughly communicating with examinees before the test to make sure they are fully motivated and concentrated on the test is of great importance for improving participants' responses and the accuracy of the polygraph test. No significant correlation was found between WMS MQ score and polygraph test accuracy in the present study, and further studies are needed to examine this problem using other more effective memory assessment instruments. The findings of the present study are not only beneficial for utilizing the polygraph more scientifically, but also for expanding its application on people with cognitive impairments.

Conflict of interest

The authors declare that they have no conflict of interest.

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