

# Correlation between Ratio of Index Finger Length to Ring Finger Length (2D:4D) and Working Memory Performance

Ananta Yudianto<sup>1</sup>, Dian Teres Agung<sup>1</sup>, Hendrik Gunawan<sup>1</sup>, and Wan YiMing<sup>2</sup>

<sup>1</sup> Faculty of Psychology Surabaya University, Surabaya, Indonesia

<sup>2</sup> Henan Institute of Science and Technology, China

Keywords: Digit Ratio 2D:4D, Working Memory.

Abstract: Ratio of Index Finger Length to Ring Finger Length (2D:4D) expressed a testosterone exposure during in prenatal. The masculinize the brain through prenatal testosterone exposure resulted a higher cognitive functioning. Previous studies shown a positive findings correlation between digit ratio (2D:4D) and cognitive functioning in gifted student sample. However rarely found study to correlate between the digit ratio (2D:4D) and working memory. We held a survey research among 22 female university students. To measure digit ratio, we employed autometric software program. Working memory was tested using computer-based Wisconsin sorting card test. Our result supported the correlation between digit ratio and working memory. Our finding implicated testosterone exposure influence working memory functioning. Mental health problem due to working memory functioning problem may detect and prevent with testosterone exposure.

## 1 INTRODUCTION

Various mental health had significant relation to working memory functioning. Several mental disorder ADHD, addiction, autism, schizophrenia, anxiety disorder were related to working memory functioning. The objective of our research is to verify the biomarker of working memory functioning through a phenotype the ratio of finger length.

Ratio of Index Finger Length to Ring Finger Length (2D:4D) expressed a testosterone exposure during in prenatal. The masculinize the brain through prenatal testosterone exposure resulted a higher cognitive functioning. Previous studies shown a positive findings correlation between digit ratio (2D:4D) and cognitive functioning (Ackermann et al., 2012; Austin, Manning, McInroy, & Mathews, 2002; Beaton, Magowan, & Rudling, 2012). Digit ratio also found this influence in spatial memory (Bull & Benson, 2006; Bull, Davidson, & Nordmann, 2010) and academic performance (Hopp, de Moraes, & Jorge, 2012).

Working memory is limited cognitive system for temporarily holding information for cognitive executive function such as decision making. Study

in gifted children shown that gifted had higher digit ratio than normal control (Durdiaková et al., 2015).

There three reasons to hold this research. First digit ratio is a consistent biomarker for the testosterone exposure in many species. However, the use of 2D:4D as an index of prenatal influence of testosterone is questioned due to inconsistency findings the effect of testosterone to cognitive functions. Testosterone is important hormone for cognitive process of memory (Cherrier et al., 2007; Ciocca et al., 2016; Davison et al., 2011; King, Kurdziel, Meyer, & Lacreuse, 2012). In other hand, There were inconsistent finding for testosterone involvement in cognitive process (Alarcón, Cservenka, Fair, & Nagel, 2014; Carré et al., 2015; Wakabayashi & Nakazawa, 2010).

Secondly, to the best knowledge of researcher, rarely found study to correlate between the digit ratio (2D:4D) and working memory.

Thirdly, the effect of testosterone is gender specific especially in prefrontal and hippocampal development (Nguyen et al., 2017). Female had advantage in testosterone influence (Postma et al., 2000). However the effect testosterone to memory in male also significantly found in animal study (Spritzer et al., 2011). Accordingly, we held this research.

## 2 METHOD

The participants of this research were 22 University student with age 18 to 21 year-old. After participant filling informed consent, we measure digit ratio and working memory. We employed autometric software program for digit ratio measurement using picture of their hand. Working memory was tested among the participant using computer-based Wisconsin card sorting test.

The procedure of data collecting as follows. First, we make picture of participant finger. The picture processed in autometric program that calculated the digit ratio index 2D:4D.

We correlated the ratio 2D4D on left and right hand and raw score of WCST including total correct, total error, number of trials, ratio difference true and false, latency and learning value. Further analysis we calculated for the curve estimation.

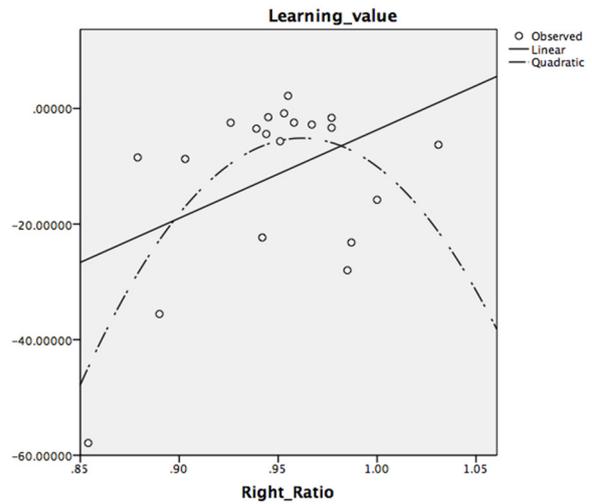
## 3 RESULT

Table 1: Correlation Score WSCL and Digit ratio 2D4D.

	Left Ratio		Right Ratio	
	r	P	R	P
TRUE	0.242	0.139	.379*	0.041
FALSE	-0.166	0.23	-.375*	0.043
True-False	0.217	0.166	.418*	0.027
Trial	-0.017	0.470	-0.170	0.225
Ratio Difference of True and False	-			
	.712**	0.001	.422*	0.025
Latency	-0.212	0.171	-0.253	0.127
Learning value	0.08	0.369	.433*	0.028

Table 2: Mean of Digit Ration 2D:4D.

Left			Right		
D2	D4	2D4D	D2	D4	2D4D
1107	1135	0.979	1114.4	1175.	0.948
.818	.318		54	227	



Graph 1: Curve Estimation

Curve estimation result shown a fit linier function of quadratic equation between right hand digit ratio and learning value WSCL.



Picture 1: Digit Ratio 2D:4D measurement using Autometric

Table: 3 Parameter for Curve estimation.

	R Square	F	df1	df2	Sig.	Constant	b1	b2
Linear	0.188	4.163	1	18	0.056	-156.574	152.865	
Quadratic	0.481	7.886	2	17	0.004	-3155.024	6548.839	-3403.883

## 4 DISCUSSION

Our result indicated positive finding correlation between right-hand digit ratio 2D4D and working memory in female participant. Thus, our finding supported brain masculinization through testosterone exposure can be predicted from digit ratio in female participant. Digit ratio was stable phenotype for testosterone exposure that influence neurodevelopmental prefrontal dan hippocampus for working memory (Liu, Bai, Xia, & Tian, 2018; Suzuki et al., 2018; Vijayraghavan, Major, & Everling, 2018).

Our finding supported practical implication of using digit ratio to detect working memory functioning especially at female right-hand finger length digit ratio (2D4D).

Our result has significant implication for health psychology to understand the biomarker for working memory function due to testosterone exposure. Testosterone exposure may a significant alternative prevention for mental health problem due to working memory problem. Two alternatives explanation testosterone influenced working memory functioning. First, testosterone exposure may influence epigenetic process to phenotype in brain structure involved the working memory functioning. Secondly, testosterone may influence directly through neurotransmitter activation (serotonergic, dopaminergic, GABAergic) that involved in working memory functioning.

Further research can be focused in mechanism of testosterone exposure to the central nervous system that support working memory functioning and epigenetic process of working memory.

## 5 CONCLUSION

Our finding supported practical implication of the use of digit ratio 2D:4D for biomarker in executive cognitive function. Due to limitation of this

preliminary study a replication study with larger sample size and broader population with different genetic background is needed in order to improve external validation of the result.

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