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DIFFERENCES ON ANTHROPOMETRIC MEASUREMENTS OF THE HAND BASED ON LATERALITY IN SERBIAN CONTEXT

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Anthropometric data are essential for designers of products, while hand anthropometric measurements are of special importance due to the fact that grasp enables different manipulation tasks. Literature review shows that differences on anthropometric characteristics of the hand based on laterality in Serbian context have not been examined till now, so this study tested it on the sample containing 110 subjects - 23 left-handed and 87 right-handed. Hand anthropometric measurements include 30 anthropometric dimensions measured on each examined participant. Dimensions are taken by capturing the imprints of the subjects' outstretched hands. Collected data were subjected to descriptive statistics, t-test, Kolmogorov test and Mann-Withney U tests. Also, 5th and 95th percentiles are calculated on all dimensions. Results show that there are no statistically significant differences based on laterality in Serbian context. Accordingly, hand tools and many other equipment, which are controlled by means of Serbian operator could be designed in the same manner both for workers whose dominant had is left and right. Also, percentiles values are calculated and should be taken into account in design processes. It is recommended, in future research to enlarge sample, repeat statistical testing and analyze hand grasp possible issues.*

Key words: hand, anthropometric measurement, left-handed, right-handed, statistical analysis

INTRODUCTION

Anthropometric data are essential for designers of products which fulfill users special needs, since it is well known that if users experience discomfort, accidents and injuries could appear [1,2]. Human laterality is very important issue which has to be examined in ergonomics field and in the hand tool design [3].

The human hand is very important executor of locomotor function, especially in tasks of manipulation. Hand has specific configuration of the bones and muscles which enables opposition of the pulp surface of the thumb to the surfaces of the other four finger tips in a firm grasp. Hand discomfort, disorders and injuries are very frequent - hand disorders account around 30% of all injuries at work, 25% of lost work time, and 20% of permanent disabilities [4]. Hand discomfort and injuries are provoked by task which requires a hand strength that exceeds the worker's capability, awkward posture, and repetitive task [5].

Accordingly, anthropometric dimensions and hand grip strength are critical parameters that need to be considered when designing ergonomic products and the aim of this paper is to check if there are significant differences between left handed and right handed persons' hand anthropometric dimensions. This paper is structured as follows. After topic introduction in this section, literature, which is scarce, review is given in the next section, while in section 3 methodology is described, implemented and results are given, while the last, forth section gives discussion and conclusions.

LITERATURE REVIEW

Available literature on differences between hand anthropometric measurements between left and right handed users is scarce and just touches topic of interest. Kawaguchi et al. emphasize importance of hand anthropometry for the grasp, such as stability, easiness and fitness of the grasp, for certain products [6]. Boz et al. have analyzed relationship between the body mass index (BMI), wrist index and hand anthropometric measures and come to conclusion that differences in the hand length/height ratio were not statistically significant between female and male study participants [7]. Barut et al. have compared hand anthropometric measurements and grip strength between different sports professions and found statistically significant differences for right and left hand width, right finger index, right hand, length/height, left hand length/height values between basketball, handball and volleyball players [8]. Kulaksiz & Gözil investigated hand preference based on seven parameters of hand anthropometric measurements and concluded that there are no differences between sex, while influential factors such on hand preference are hand activity, hormones, and brain asymmetry [9].

On other side, numerous studies on hand grip strength have been carried till today. Data are usually divided into age and gender sub-groups and it evident that the highest hand grip strength have male persons in forties [10,11]. Also, certain research claim positive relationship between hand grip strength and BMI, while other do not find significant between subjected parameters [12].

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One of rare studies which compare left and right hand anthropometric dimensions is done by Cakit et al. on sample consisting of of 92 male and 73 female students at dentistry faculty in Turkey [13]. Authors Cakit et al. have found that the mean values of fingerbreadths, finger circumferences, and hand depths are significantly larger in the right hand when compared with the left hand while the mean value of handgrip strength is significantly larger in the right and when compared with the left hand [13]. Mohammad has examined 200 male and female participants in Jordan and found significant differences in hand dimensions and hand performance between left- and right-handed individuals, but without statistical hypothesis testing and based on obtained percentiles values [3]. This study is aimed to check if there are statistically significant differences between left and right hand in Serbian population.

METHODOLOGY AND RESULTS

Methodology of measurements

Anatomy of the hand is shown at Fig. 1, while dimensions measured in experiment are shown at Fig. 2. Dimensions are taken by capturing the imprints of the subjects' outstretched hands. Hand anthropometric measurements shown at Fig. 4 are obtained by combining several sources – 30 anthropometric dimensions are taken [14-17].

Participants for this study were randomly selected from the general population. Subjects selected were chosen from 19 to 50 years of age, similar to study by Mohammed [3]. The techniques of measurements were as per guidelines in NASA-1024 [19].

Figure 1: Hand joints [18]

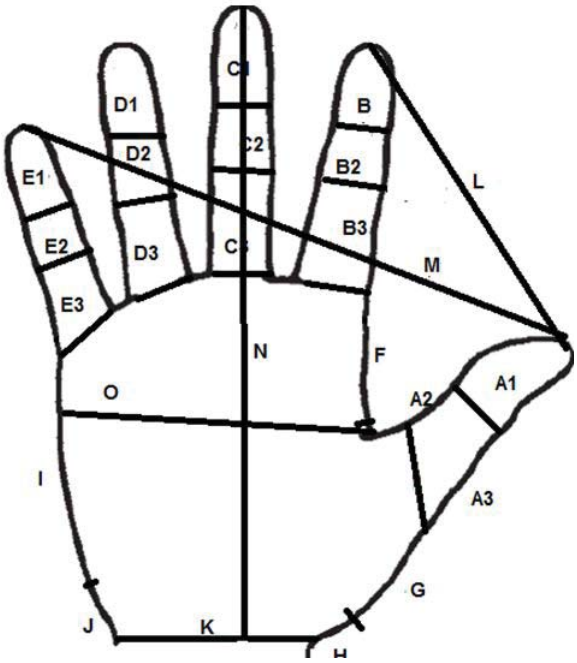

Figure 2: Hand anthropometric measurements

Measurement results and data analysis

In the first step is conducted descriptive statistics. It's includes number of subjects identification of the dominant hand (*R* - right, *L* - left), *N* number of all 110 subjects, 26 left-handed and 87 right-handed, Mean values of all measurements (see Fig. 2), Median, difference between mean and median, 5 and 95 percentile, standard deviations *SD* and Coefficient of variation in percentages *cv* [20].

Finger lengths are calculated as follows, according to Fig 1.:

$$A = A_1 + A_3,\ B = B_1 + B_2 + B_3,$$
$$C = C_1 + C_2 + C_3,\ D = D_1 + D_2 + D_3,\quad (1)$$
$$E = E_1 + E_2 + E_3$$

Descriptive statistics of all measures for all subjects is shown at Tab. 1. Since coefficients of variation are all smaller than 30%, data are homogeneous. Also, differences between means and medians are small (less than 1 mm) it can be concluded that data are symmetrical. Thus it can be assumed that all measured data are normally distributed.

In order of further comparisons measured hand dimensions are divided on left-handed users and right-handed users Tables 2 and 4. Parametric variables indicate that parametric methods for comparisons are used, i.e. t-test, since number of left-handed users is smaller than 30.

In the case of left-handed users differences between mean and median for measurements *B, C_3, E_3, G, I, L* and *M* (see Fig. 4) are greater than 1 mm, and for them Kolmogorov test for normality is conducted, since all data are homogeneous, i.e. values of coefficient of variation are smaller than 30%. Obtained results are shown in Table 3.

Conducted Kolmogorov test for normality shows that all measures except *L*, in spite differences larger than 1 mm

Table 1: Descriptive statistics of all measures for all subjects

	N	Mean	Median	Me-Med	5%	95%	SD	cv[%]
A_1	110	34.605	35.00	0.395	26	42	4.660	13.47
A_2	110	21.555	22.00	0.445	15	28	4.185	19.42
A_3	110	34.509	34.00	0.509	26	43	5.414	15.69
A	110	69.114	69.00	0.114	56	81	7.628	11.04
B_1	110	25.859	26.00	0.141	21	31	3.378	13.06
B_2	110	22.359	22.00	0.359	17	29	3.686	16.48
B_3	110	28.591	29.00	0.409	22	35	4.360	15.25
B	110	76.809	77.00	0.191	66	88	6.751	8.79
C_1	110	26.423	26.00	0.423	22	32	3.899	14.76
C_2	110	26.673	27.00	0.327	21	33	3.566	13.37
C_3	110	30.973	30.25	0.723	24	39	4.263	13.76
C	110	84.068	84.00	0.068	73	96	7.541	8.97
D_1	110	24.050	24.00	0.050	20	29	3.036	12.62
D_2	110	25.500	26.00	0.500	20	32	3.857	15.13
D_3	110	28.045	28.00	0.045	21	35	4.339	15.47
D	110	77.595	76.75	0.845	65	90	6.995	9.01
E_1	110	21.268	21.00	0.268	17	27	3.163	14.87
E_2	110	18.814	19.00	0.186	14	24	3.382	17.98
E_3	110	21.695	21.25	0.445	16	28	3.623	16.70
E	110	61.932	61.00	0.932	53	72	6.358	10.27
F	110	32.368	32.00	0.368	22	42	5.952	18.39
G	110	33.964	34.00	0.036	21	46	6.980	20.55
H	110	17.053	17.00	0.053	12	24	3.853	22.59
I	110	50.486	50.50	0.014	33	66	9.837	19.48
J	110	21.268	21.00	0.268	13	32	4.913	23.10
K	110	58.964	59.50	0.536	45	75	9.727	16.50
L	110	102.66	103.00	0.336	80	128	14.64	14.26
M	110	171.21	172.00	0.791	143	203	19.30	11.27
N	110	186.64	186.00	0.645	166	213	13.98	7.49
O	110	91.900	92.50	0.600	78	105	8.911	9.70

Table 3: Kolmogorov test for left-handed users

Measurement	p-value	significance	Variable type
B	0.5867	n.s.	parametric
C3	0.4798	n.s.	parametric
E	0.147	n.s.	parametric
G	0.589	n.s.	parametric
I	0.528	n.s.	parametric
L	0.038	<0.05	non-parametric
M	0.897	n.s.	parametric

between their mean and median are parametric, while *L* is non-parametric variable. Also *L* is largely subjective measure no templates are used.

In the case of right-handed users, differences between

Table 2: Descriptive statistics for left-handed users

	N	Mean	Median	Me-Med	5%	95%	SD	cv[%]
A_1	23	34.522	35.00	0.478	26	41	5.806	16.82
A_2	23	21.130	22.00	0.870	15	25	3.946	18.68
A_3	23	34.717	35.00	0.283	28	44	5.180	14.92
A	23	69.239	70.00	0.761	56	80	8.504	12.28
B_1	23	26.065	26.00	0.065	22	31	3.379	12.96
B_2	23	22.826	23.00	0.174	19	26	2.516	11.02
B_3	23	28.435	28.00	0.435	23	33	3.883	13.65
B	23	77.326	79.00	1.674	68	86	6.778	8.77
C_1	23	26.913	26.50	0.413	23	31	2.949	10.96
C_2	23	26.935	27.00	0.065	22	30	3.113	11.56
C_3	23	31.435	30.00	1.435	27	37	3.527	11.22
C	23	85.283	85.00	0.283	77	95	5.803	6.80
D_1	23	24.261	24.00	0.261	20	28	2.580	10.63
D_2	23	26.130	27.00	0.870	19	32	3.900	14.92
D_3	23	26.826	26.00	0.826	21	33	3.701	13.80
D	23	77.217	78.00	0.783	68	86	5.720	7.41
E_1	23	21.652	22.00	0.348	18	25	2.745	12.68
E_2	23	19.630	20.00	0.370	15	24	3.192	16.26
E_3	23	21.261	20.00	1.261	16	28	3.532	16.61
E	23	62.413	62.00	0.413	53	75	6.687	10.71
F	23	34.130	34.00	0.130	26	42	4.605	13.49
G	23	33.087	32.00	1.087	21	47	8.163	24.67
H	23	18.130	18.00	0.130	14	24	2.989	16.49
I	23	51.152	56.00	4.848	32	66	11.95	23.36
J	23	20.565	20.00	0.565	13	28	5.035	24.48
K	23	57.435	57.00	0.435	48	70	6.828	11.89
L	23	105.74	104.0	1.739	92	127	13.66	12.92
M	23	176.04	172.0	4.043	147	203	18.47	10.49
N	23	188.65	192.0	3.348	161	208	13.15	6.97
O	23	91.304	91.00	0.304	81	103	7.339	8.04

mean and median for measurements *D*, *E, L* and *N* (see Fig. 2) are greater than 1 mm, and for them is conducted Kolmogorov test for normality, since all data are homogeneous, i.e. values of coefficient of variation are smaller than 30%. Obtained results are shown in Tab. 5.

For right-handed users overall length of the small finger (*E*) is nonparametric measurement, as well as a hand length, which can be explained by measurement of dimension *K*, and positioning of middle finger at the imprints.

According Tab. 2 and Tab. 4 for comparisons of the measurements *E*, *L* and *N* is conducted by use of Mann-Withney U* tests. Otherwise for comparisons *t*-tests for independent samples are used.

Comparison between left and right hand measurements using student t-test are presented in Table 6., while measurements where Mann-Withney U* test is used are presented at Tab. 7.

Table 4: Descriptive statistics for right-handed users

	N	Mean	Median	Me-Med	5%	95%	SD	cv[%]
A_1	87	34.626	34.00	0.63	28	42	4.347	12.55
A_2	87	21.667	22.00	0.33	16	28	4.261	19.67
A_3	87	34.454	34.00	0.45	25	42	5.502	15.97
A	87	69.080	69.00	0.08	57	81	7.433	10.76
B_1	87	25.805	26.00	0.20	20	31	3.395	13.16
B_2	87	22.236	22.00	0.24	17	29.5	3.940	17.72
B_3	87	28.632	29.00	0.37	22	35	4.498	15.71
B	87	76.672	77.00	0.33	65	88	6.777	8.84
C_1	87	26.293	26.00	0.29	22	33	4.119	15.66
C_2	87	26.603	27.00	0.40	21	33	3.689	13.87
C_3	87	30.851	30.50	0.35	24	39	4.447	14.41
C	87	83.747	83.00	0.75	71	96	7.935	9.47
D_1	87	23.994	24.00	0.01	19	29	3.156	13.15
D_2	87	25.333	25.00	0.33	20	32	3.851	15.20
D_3	87	28.368	29.00	0.63	21	35	4.456	15.71
D	87	77.695	76.50	1.20	65	90	7.320	9.42
E_1	87	21.167	21.00	0.17	17	27	3.271	15.46
E_2	87	18.598	19.00	0.40	14	25	3.416	18.37
E_3	87	21.810	21.50	0.31	17	28	3.659	16.77
E	87	61.805	60.50	1.30	53	72	6.302	10.20
F	87	31.902	31.00	0.90	22	42	6.199	19.43
G	87	34.195	34.00	0.20	22	45	6.666	19.49
H	87	16.768	17.00	0.23	11	24	4.017	23.96
I	87	50.310	50.00	0.31	34	66	9.272	18.43
J	87	21.454	21.00	0.45	14	32	4.893	22.81
K	87	59.368	60.00	0.63	42	75	10.354	17.44
L	87	101.85	100.00	1.85	80	128	14.852	14.58
M	87	169.93	170.00	0.07	143	198	19.412	11.42
N	87	186.11	184.00	2.11	168	217	14.213	7.64
O	87	92.057	93.00	0.94	76	106	9.314	10.12

Table 5: Kolmogorov test for left-handed users

Measurement	p-value	significance	Variable type
D	0.279	n.s.	parametric
E	0.0218	<0.05	non-parametric
L	0.1898	n.s.	parametric
N	0.0202	<0.05	non-parametric

Both types of comparisons, using parametric and non-parametric methods (Tab. 6 and Tab. 7) show that there are no statistically significant differences between measurements that consider dominant hands within group of 110 subjects, 23 left-handed and 87 right-handed.

CONCLUSION

This is first study of hand anthropometric measurements for Serbian population. This study examined hand anthropometric measurements on the sample containing 110 subjects - 23 left-handed and 87 right-handed.

Table 6: Comparisons between left and right hand measurements using t-test

Comparison	t-statistics	p-value	significance
AL_1 vs. AR_1	-0.0954	0.924	n.s.
AL_2 vs. AR_2	-0.5447	0.587	n.s.
AL_3 vs. AR_3	0.2066	0.837	n.s.
AL vs. AR	0.0883	0.930	n.s.
BL_1 vs. BR_1	0.3277	0.744	n.s.
BL_2 vs. BR_2	0.6816	0.497	n.s.
BL_3 vs. BR_3	-0.1922	0.848	n.s.
BL vs. BR	0.4114	0.682	n.s.
CL_1 vs. CR_1	0.6764	0.500	n.s.
CL_2 vs. CR_2	0.3948	0.694	n.s.
CL_3 vs. CR_3	0.5828	0.561	n.s.
CL vs. CR	0.8675	0.388	n.s.
DL_1 vs. DR_1	0.3731	0.710	n.s.
DL_2 vs. DR_2	0.8805	0.381	n.s.
DL_3 vs. DR_3	-1.5246	0.130	n.s.
DL vs. DR	-0.2902	0.772	n.s.
EL_1 vs. ER_1	0.6530	0.515	n.s.
EL_2 vs. ER_2	1.3065	0.194	n.s.
EL_3 vs. ER_3	-0.6451	0.520	n.s.
FL vs. FR	1.6082	0.111	n.s.
GL vs. **GR**	-0.6757	0.501	n.s.
HL vs. HR	1.5174	0.132	n.s.
IL vs. IR	0.3635	0.717	n.s.
JL vs. JR	-0.7701	0.443	n.s.
KL vs. KR	-0.8465	0.399	n.s.
ML vs. MR	1.3561	0.178	n.s.
OL vs. OR	-0.3590	0.720	n.s.
Note: L - left hand, while R - right hand			

*Table 7: Comparisons between left and right hand measurements using Mann-Whitney U*test*

Comparison	Z* statistic	p-value	significance
EL vs. ER	-1.389	0.1649	n.s.
LL vs. LR	0.000	1.0000	n.s.
NL vs. NR	0.000	1.0000	n.s.

Therefore:

- Extended statistical analysis was conducted for all 30

measured dimensions, that include additional measurement such as difference between mean and median, and also 5th and 95th percentiles are calculated ;

- Same descriptive statistics was conducted for all of 23 left-handed and 87 right handed users;
- Depending of hand, for some measures difference between mean and median was larger than 1 mm, and for them was conducted Kolmogorov test for normality was conducted resulting with one of 7 measures for left-handed and 2 of four measures right-handed users had non-normal distribution;
- In the cases of the comparisons of the normal distributions, t-test for independent samples were used, otherwise non-parametric Mann-Withney U* test was conducted (3 comparisons);
- All results show no statistically significant difference between measures.

According to this study, using parametric and non-parametric methods, there are no evidenced statistically significant differences between subjects, so hand tools and other equipment which are controlled by means of Serbian operator hand could be designed in the same manner both for workers whose dominant hand is left and right. In those tasks, obtained percentiles values have to be taken into account when designing tools.

It is recommended, in future research to enlarge sample and repeat statistical testing. Also, hand grasp laterality issues are possible future research avenue.

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REFERENCES

1. Spasojevic-Brkic, V., Veljkovic, Z., Essdai, A. A., & Brkic, A. [2019]. Differences in anthropometric measurements between Libyan and Serbian passenger car drivers and crane operators. *Journal of Applied Engineering Science*, vol. 17(1), 1-7.
2. Spasojevic-Brkic, V. K., Veljkovic, Z., & Brkic, A. [2015]. Crane Cabins's Safety and Ergonomics Characteristics Evaluation Based on Data Collected in Sweden Port. J*ournal of Applied Engineering Science*, 13(4), 299-306.
3. Mohammad, Y. A. (2005). Anthropometric characteristics of the hand based on laterality and sex among Jordanian. International Journal of Industrial Ergonomics, vol. 35, no. 8, 747-754, DOI: 10.1016/j.ergon.2004.11.005
4. Lee, K. S., & Jung, M. C. (2015). Ergonomic evaluation of biomechanical hand function. Safety and health at work, vol. 6, no. 1, 9-17, DOI: 10.1016/j.shaw.2014.09.002
5. Seo, N. J., Sindhu, B. S., & Shechtman, O. (2011). Influence of pain associated with musculoskeletal disorders on grip force timing. Journal of hand therapy, vol. 24, no. 4, 335-344, DOI: 10.1016/j.jht.2011.06.004
6. Kawaguchi, K., Endo, Y., & Kanai, S. (2009, July). Database-driven grasp synthesis and ergonomic assessment for handheld product design. In International Conference on Digital Human Modeling (pp. 642-652). Springer, Berlin, Heidelberg, DOI: 10.1007/978-3-642-02809-0_68
7. Boz, C., Ozmenoglu, M., Altunayoglu, V., Velioglu, S. K., & Alioglu, Z. (2004). Individual risk factors for carpal tunnel syndrome: an evaluation of body mass index, wrist index and hand anthropometric measurements. Clinical neurology and neurosurgery, vol. 106, no. 4, 294-299, DOI: 10.1016/j.clineuro.2004.01.002
8. Barut, C., Demirel, P., & Kıran, S. (2008). Evaluation of hand anthropometric measurements and grip strength in basketball, volleyball and handball players. Anatomy, vol. 2, no. 1, 55-59, DOI: 10.2399/ana.08.055
9. Kulaksiz, G., & Gozil, R. (2002). The effect of hand preference on hand anthropometric measurements in healthy individuals. Annals of Anatomy-Anatomischer Anzeiger, vol. 184, no. 3, 257-265, DOI: 10.1016/S0940-9602(02)80119-4
10. Angst, F., Drerup, S., Werle, S., Herren, D. B., Simmen, B. R., & Goldhahn, J. (2010). Prediction of grip and key pinch strength in 978 healthy subjects. BMC musculoskeletal disorders, vol. 11, no. 1, art. 94, DOI: 10.1186/1471-2474-11-94
11. Bohannon, R. W., & Schaubert, K. L. (2005). Test–retest reliability of grip-strength measures obtained over a 12-week interval from community-dwelling elders. Journal of hand therapy, vol. 18, no. 4, 426-428, DOI: 10.1197/j.jht.2005.07.003
12. Koley, S., Kaur, N., & Sandhu, J. S. (2009). A study on hand grip strength in female labourers of Jalandhar, Punjab, India. Journal of Life Sciences, vol. 1 no. 1, 57-62, DOI: 10.1080/09751270.2009.11885135
13. Cakit, E., Durgun, B., Cetik, O., & Yoldas, O. (2014). A survey of hand anthropometry and biomechanical measurements of dentistry students in Turkey. Human Factors and Ergonomics in Manufacturing & Service Industries, vol. 24, no. 6, 739-753, DOI: 10.1002/hfm.20401
14. Choi, H. S., & Choi, Y. H. (2016). Accuracy of Tablet Counts Estimated by Members of the Public and Healthcare Professionals. Journal of The Korean Society of Emergency Medicine, vol. 27, no. 1, 69-74

15. Hisao, H., Whitestone, J., Kau, T. Y., & Hildreth, B. (2015). Firefighter hand anthropometry and structural glove sizing: a new perspective. Human factors, vol. 57, no. 8, 1359-1377, DOI: 10.1177/0018720815594933
16. Mora, M. C., Sancho-Bru, J. L., & Perez-Gonzalez, A. (2012). Hand posture prediction using neural networks within a biomechanical model. International Journal of Advanced Robotic Systems, vol. 9, no. 4, 139, DOI: 10.5772/52057
17. Pheasant, S., & Haslegrave, C. M. (2005). Bodyspace: Anthropometry, ergonomics and the design of work. CRC press.
18. Xiong, C. H., Chen, W. R., Sun, B. Y., Liu, M. J., Yue, S. G., & Chen, W. B. (2016). Design and implementation of an anthropomorphic hand for replicating human grasping functions. IEEE Transactions on Robotics, vol. 32, no. 3, 652-671, DOI: 10.1109/TRO.2016.2558193
19. NASA (1978), Anthropometric Source Book, Anthropology Research Project. Anthropometric source book (Vol. 2). National Aeronautics and Space Administration, Scientific and Technical Information Office. Washington
20. Montgomery, D. C., & Runger, G. C. (2013). Applied statistics and probability for engineers, (6 ed). John Wiley & Sons.

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