The effect of health literacy on COVID-19 vaccine hesitancy among community population in China: The moderating role of stress

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ABSTRACT

Background: The public's hesitant attitude is a major subjective barrier in promoting vaccination against COVID-19 to build herd immunity. The current study aimed to address how individual factors such as health literacy and perceived stress affect people's vaccine hesitancy of COVID-19 vaccine, and to provide insights for tailoring vaccine-promotion strategies.
Methods: With structured questionnaires, an online survey was conducted to address the relationship between the health literacy, perceived stress, and COVID-19 vaccine hesitancy among community population in mainland, China. Moderated analysis was conducted to test the effect of health literacy on vaccine hesitancy among people with different levels of perceived stress.
Results: 560 responses were collected in total. 39.8% of the participants reported vaccine hesitancy, and this rate was higher among younger people and female. Moreover, people with higher level of health literacy showed reduced vaccine hesitancy, while this effect was only significant among those with low or moderate level of stress. For people with high level of stress, no significant effect of health literacy was found.
Conclusions: The findings suggest that increasing people's health literacy could lead to reduced vaccine hesitancy in community sample. However, this effect disappeared when the stress level was high, suggesting other promotion services may need to be developed to increase the acceptance of COVID-19 vaccine. In conclusion, vaccine promotion strategies should be tailored for different populations, with taking account of individual's health literacy and perceived stress.

1. Introduction

March 11, 2020, the World Health Organization (WHO) has declared COVID-19 as a pandemic [1], and up till 11 January 2022, over 311 million infected cases and 6 million casualties were reported in 222 countries and regions [2]. The disease is notable for its rapid transmission, extensive incubation period (2–14 days), as well as the high infectionability for all individuals regardless of gender or age [3]. In addition to a public health crisis, COVID-19 also has immense impacts on the global economy and financial markets due to reduced productivity, business closures, trade disruption, etc. [4]. To mitigate the impact of this pandemic, strengthening public immunity is the key.

Based on the experience in fighting against infectious diseases such as polio, smallpox, etc., vaccination was considered to be the most effective and economical way to build herd immunity. Despite that the possibility of achieving herd immunity has remained inconclusive [5,6], the importance and necessity of vaccination is undeniable [7,8]. In May 2020, WHO has issued the 73th World Health Assembly that recognized the significance of extensive immunization in preventing, containing, and stopping transmission of COVID-19 [9]. Up to the date of this survey (31 January 2021), the vaccination rate was 19.85% in Israel, 3.85% in the USA, and only 0.75% in China [10], far from the expected vaccination rate of 70% for building group immunity. Even looking at the latest vaccination data (26 December 2021), the global population who has been fully vaccinated was 50% worldwide [11]. In addition to the objective barriers (e.g., some African countries may be suffered from vaccine apartheid, or insufficient supply of vaccine [12]), vaccine hesitancy was a major obstacle in promoting the vaccination against COVID-19 [13,14].

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Vaccine hesitancy was referred as the intentional postponement or refusal of vaccination despite the availability of vaccination services [15]. People's vaccine hesitancy was influenced by complex contextual, individual, and vaccine-specific factors [15]. Previous research has developed a '5Cs' framework to explain individual-level determinants of vaccine hesitancy, including confidence, complacency, convenience, risk calculation, and collective responsibility [16]. Recent research has extended the '5Cs' to a '7Cs' model by including conspiracy and compliance [17]. However, this framework is primarily based on samples from high-income countries, and may not be applied to middle or low-income countries. Furthermore, understanding the modifiable individual determinants of people's hesitation to vaccines is critical in promoting the booster shot when facing the emergence of new virus variants [18]. Health literacy, defined as the cognitive and social skills that identify an individual's motivation and ability to access, understand, and apply health information to maintain and promote health [19], was considered to be a critical psychosocial contributors to people's health behaviors. In the context of the COVID-19 pandemic, health literacy was found positively related to the capacity to adopt preventive measures such as taking vaccines [20,21], wearing face masks [22], or keeping social distancing. Based on the concept of health literacy [23], 'vaccine literacy' or 'vaccine-related health literacy' may refer to individuals' knowledge, motivation, and skills to find, understand, and evaluate immunization-related information in order to make adequate immunization decisions [21,24].".

However, recent findings on the relationships between health literacy and attitudes towards the COVID-19 vaccine has remained mixed. Some studies suggested that health literacy contributed to the increased willingness to be vaccinated [25]. People with better health literacy, especially those with higher vaccine literacy, reported reduced hesitation [26], uncertainty, or refusal to receive the COVID-19 vaccine [27]. However, in a recent systematic review by Lorini et al., (2018), it was found that the relationship between health literacy and vaccination has remained unclear [28]. To explain the inconsistent results, it is possible that health literacy may lead to both higher confidence and risk calculations, which affect people's attitudes in different directions. On the other hand, potential moderating factors in the effects of health literacy should be considered, for example, individual's perceived stress. A previous study showed that during the COVID-19 pandemic outbreak, nurses' stress level may have influenced their intention to be vaccinated [29]. In particular, high levels of stress among nurses were found to be associated with greater acceptance of vaccine against COVID-19. A study of emergency healthcare workers showed that intent/uptake was lower among those with high perceived stress/vulnerability [30]. Another study of Polish healthcare workers reported that stress didn't affect the intention to be vaccinated [31]. Rather than samples of healthcare workers, a study with general public showed no association between stress and vaccine acceptance [32]. The abovementioned studies suggested that the relationship between health literacy and vaccine attitude could be complicated, and stress could also play a role in people's attitude toward COVID-19 vaccine.

The present study has two-fold research purposes: 1) to investigate the effect of health literacy on people's attitude towards COVID-19 vaccination; 2) to address the interaction between stress and health literacy in influencing vaccine hesitancy. We hypothesized that higher health literacy is associated with reduced COVID-19 vaccine hesitancy, and this effect will be moderated by an individual's perceived stress. The findings would provide insights for developing intervention programs to promote public's uptake of vaccination, and hopefully, helping build herd immunity to control the spread of COVID-19.

2. Method

2.1. Sample and data collection

A cross-sectional survey was conducted to examine the relationships between health literacy, perceived stress, and vaccine hesitancy in a community-based population in mainland China. From 25 January to 8 February 2021, participants from 135 cities with different income levels were recruited using a multi-centre cluster sampling method. Emails and messages containing link to the online survey was disseminated via flyers and online advertisements. The online anonymous survey was implemented with Wenjuanxing, a professional data collection platform accredited by top international journals in the fields of psychology, management, sociology, and environmental health. A total five hundred and sixty-two responses were collected. Participants were asked to respond if 1) they are 18 or above; 2) their native language is Chinese; 3) they were located in mainland China, during the COVID-19 outbreak; and 4) they had no significant cognitive or visual impairment. Two responses from participants under the age of 18 were removed (0.4%). They were informed to provide an electronic signature before taking part in the survey (only their family name was required in the signature for their privacy). After completing the survey, drawing lots would be used to decide whether the participant would receive an incentive of 20 RMB (approximately equal to 3 USD). For those who were lucky, the payment would be transferred via the online platform. The survey was approved by the XXX University Research Ethics Committee (blinded for review).

2.2. Measurement

Participant's demographic characteristics, including age, gender, marital status, and education level, as well as their chronic illness, and health behaviors, were collected as potential covariates. The participants were also asked about the reason why they are hesitant for taking COVID-19 vaccine.

COVID-19 vaccine hesitancy was measured by a revised questionnaire from the Parents Attitudes About Childhood Vaccines (PACV, [33]) and the Vaccine Confidence Index (VCI, [34]). Participant's attitudes towards the COVID-19 vaccine were assessed by seven items such as "I think the COVID-19 Vaccine is safe" or "I think vaccination is an important preventive measure to prevent COVID-19". A 3-point Likert scale was used, with responses ranging from "0" (agree or strongly agree), "1" (unsure), and "2" (disagree or strongly disagree). A total score of vaccine hesitancy was obtained and transformed into an index with the formula $[I = Mean \times 15]$ [35]. The transformed vaccine hesitancy index ranges from 0 to 30, with higher scores indicating more vaccine hesitancy [33,36]. A vaccine hesitancy index of 0 to 15 indicates "do not hesitate", and 16 to 30 indicates "hesitate". Previous studies with Chinese samples have shown that this measure has good validity and reliability [37], and in our sample, the Cronbach alpha is 0.637, suggesting an acceptable reliability.

Health literacy was measured using the 12-item short version of HLS-EU-Q [38], which evaluates people's information processing skills in the areas of health-promotion, healthcare and disease prevention. To assess vaccine literacy, we have also extracted the 3 vaccine-related items from the full version of HLS-EU-Q ("I can understand why I need to be vaccinated", "I can find information about vaccinations", and "I can make a decision about whether to get a flu vaccination"), and in total, there were 15 items in the HL measurement. A 4-point Likert scale was used, with responses ranging from "1" (very difficult) to "4" (very easy), and "do not know" was coded as a missing value. Mean scores was obtained

to indicate the individual's level of health literacy, with higher scores indicating better health literacy [39]. The Cronbach alpha in our sample was 0.936, suggesting good internal consistency.

Perceived stress was measured by the Chinese Perceived Stress Scales (CPSS) [40]. Based on the Perceived Stress Scale (PSS) [41], the CPSS has been revised and culturally adapted for use in China. There are 14 items in total, including "Feeling out of control of important things in life" and "Feeling that the problems are accumulating and difficult to solve". A 4-point Likert scale was used, with responses ranging from "1" (never) to "4" (frequently), with higher scores indicating greater perceived stress. 1SD Above mean indicates high stress and 1SD below indicates low stress, with a score in between for moderate stress. Previous research has showed that the CPSS has good reliability and validity in community samples [42–44].

2.3. Statistical analysis

Data analysis was conducted using SPSS (Statistical Package for the Social Sciences) 21.0 and Process MACRO. A liner regression model was performed to assess the main effects of health literacy on vaccine hesitancy and the moderating effects of perceived stress. Results are shown for unadjusted and adjusted models, which controlled for gender, education, age, marital status, chronic conditions, and health behaviors.

3. Results

A total of 560 valid responses were included (The descriptive results are shown in Table 1). The majority of the participants were female (70.0%) and the mean age was 30.25 years (SD = 13.92). 22.7% of the participants were married and 79.5% had obtained a university degree or higher. The mean vaccine hesitancy score was 12.11 (SD = 5.69), with 39.8% of participants showed hesitancy. Regarding the reasons people had for vaccine hesitancy, 62.5% were worried about the safety of vaccine, 46.4% had concerns that the COVID-19 vaccine may be ineffective, and 14.3% were hesitant because of the inconvenience of taking vaccine. The average health literacy score was 3.22 (SD = 0.46), suggesting that most people chose a response between "easy" and "very easy" when they had different abilities to process health information. The correlation between vaccine hesitancy and other variables was presented in Table 2.

Unadjusted and adjusted regression models were conducted to test the effect of health literacy on vaccine hesitancy. In the unadjusted model, a significant negative effect of health literacy was found on vaccine hesitancy was found (β = -1.71, *SE* = 0.52, *p* = 0.001, 95% CI (Confidence Level) = [-2.74, −0.68]). When controlling for age, sex, education, marital status, chronic condition, and health behavior, younger and female were found to be associated with higher levels of vaccine hesitancy (age: β = -0.07, *SE* = 0.03, *p* = 0.02, 95% CI = [-0.13, −0.01]; sex: β = 1.54, *SE* = 0.51, *p* = 0.002, 95% CI = [0.55, 2.53]). In the adjusted models controlling for the covariates, the main effect of health literacy remained significant, predicting a reduction in vaccine hesitancy (β = -2.00, *SE* = 0.52, *p* < 0.001, 95% CI = [-3.00, −0.99]).[2] Regression models are shown in Table 3.

The moderating role of perceived stress in the relationship between health literacy and vaccine hesitancy was tested with Model 1, Process MACRO. The main effects of health literacy remained significant (β = -6.25, *SE* = 1.68, *p* < 0.001, 95%

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[2] The mean score of three vaccine-related health literacy items was also generated to indicate vaccine-related health literacy. However, no significant effect was found of it in either adjusted or unadjusted model predicting vaccine hesitancy. Therefore, only the effect of overall health literacy was reported.

Table 1
Descriptive statistics for all variables. Means and standard deviations reported for interval and ordinal variables, proportions for nominal or binary variables (N = 560).

Group	N (% of sample) Mean ± S.D.	Range
Sex		
Male (0)	168(30.0%)	
Female (1)	392(70.0%)	
Age	30.25 ± 13.92	18–90
Marital status		
Married (0)	126(22.5%)	
Single/divorced/separated/widowed/others (1)	434(77.5%)	
Educational level		1–4
Uneducated	4(0.7%)	
Primary school	10(1.8%)	
High school	101(18.0%)	
University or college and above	445(79.5%)	
Chronic conditions		
Having chronic conditions (0)	120(21.4%)	
Not having (1)	440(78.6%)	
Health behaviors		
Frequent physical exercise	200(35.7%)	
Non-smoking	520(92.9%)	
Non-drinking	517(92.3%)	
Regular physical examination	181(32.3%)	
Health Literacy	3.22 ± 0.46	1, 4
Perceived Stress	23.26 ± 7.87	0, 45.5
Vaccine Hesitancy	12.11 ± 5.69	0, 30
Reasons for Vaccine Hesitancy		
Inconvenience	8(14.3%)	
Worry about ineffective	26(46.4%)	
Worry about the safety of vaccine	35(62.5%)	

CI = [-9.56, −2.94]), and the main effect of stress was also significant (β = -0.56, *SE* = 0.22, *p* = 0.01, 95% CI = [-1.00, −0.12], suggesting that better health literacy and greater perceived stress were associated with lower vaccine hesitancy. The main effects were accounted for by an interaction effect ($\beta_{HL* Stress}$ = 0.18, *SE* = 0.07, *p* = 0.007, 95% CI = [0.05, 0.32]), indicating that the effect of health literacy differed between people with different levels of perceived stress (see Fig. 1). By probing the interaction effects, simple effect analysis revealed that only health literacy was associated with lower vaccine hesitancy only when perceived stress levels were moderate or low (low stress: β = -3.43, *SE* = 0.77, *p* < 0.001, 95% CI = [-4.95, −1.92]; moderate stress: β = -1.98, *SE* = 0.52, *p* < 0.001, 95% CI = [-3.00, −0.97]), and the effect of health literacy became non-significant when the perceived stress level was high (β = -0.53, *SE* = 0.71, *p* = 0.45, 95% CI = [-1.94, 0.87]).

4. Discussion

By conducting a structured online survey, this study investigated how health literacy influences people's hesitancy to COVID-19 vaccine, and addressed the moderating role of perceived stress in this relationship. In our sample, 39.8% of people reported hesitant attitude toward the COVID-19 vaccine, particularly among women and younger people. Individuals with better health literacy were less likely to show hesitation to COVID-19 vaccination, and this effect was moderated by stress, such that when stress level was high, the effect of health literacy on reducing vaccine hesitancy disappeared.

Existing literature has found COVID-19 vaccine hesitancy and acceptance varied across different demographic groups. Approximately 40% of our sample showed vaccine hesitancy, and this rate is close to that reported by previous studies in China (35.5%) [45], the United States (42.4%) [46], Turkey (44.5%) [47], and Malta (48.2%) [48]. This rate was much lower in low- and middle- income

Table 2
The correlation matrix between variables.

Group	Sex	Age	Marital status	Educational level	Chronic conditions	Health behaviors	Health Literacy	Perceived Stress	Vaccine Hesitancy
Sex	1								
Age	−0.077	1							
Marital status	0.058	−0.668 ***	1						
Educational level	0.174 **	−0.457 ***	0.524 ***	1					
Chronic conditions	0.057	−0.265 ***	0.243 ***	0.228 ***	1				
Health behaviors	0.002	0.333 ***	−0.283 ***	−0.175 ***	−0.142 **	1			
Health Literacy	0.014	−0.094 *	0.060	0.129 **	0.022	0.067	1		
Perceived Stress	−0.034	−0.234 ***	0.167 ***	0.110 **	−0.017	−0.160 ***	−0.151 ***	1	
Vaccine Hesitancy	0.123 **	−0.235 ***	−0.203 ***	0.194 ***	0.092 *	−0.139 **	−0.137 **	−0.137 **	1

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 3
Results of regression model predicting vaccine hesitancy.

| Group	Null Model β(95 %C.I.)	HL Model β(95 %C.I.)	Interaction Model β(95 %C.I.)
Sex	1.51(0.50, 2.51) **	1.54(0.55, 2.53) **	1.53(0.55, 2.53) **
Age	−0.06(-0.12, −0.01) **	−0.07(-0.13, −0.01) *	−0.06(-0.12, −0.004) *
Marital status	0.80(-0.94, 2.53)	0.71(-1.01, 2.43)	0.62(-1.10, 2.33)
Educational level	0.11(-1.11, 1.32)	0.36(-0.86, 1.57)	0.46(-0.75, 1.67)
Chronic condition	−0.13(-1.35, 1.10)	−0.13(-1.35, 1.10)	−0.08(-1.31, 1.14)
Health behavior	−0.55(-1.18, 0.08)	−0.47(-1.10, 0.16)	−0.43(-1.06, 0.20)
Health Literacy (HL)		−2.00(-3.00, −0.99) ***	−6.25(-9.56, −2.94) ***
Perceived Stress			−0.56(-1.00, −0.12) *
HL* Stress			0.18(0.05, 0.32) **

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
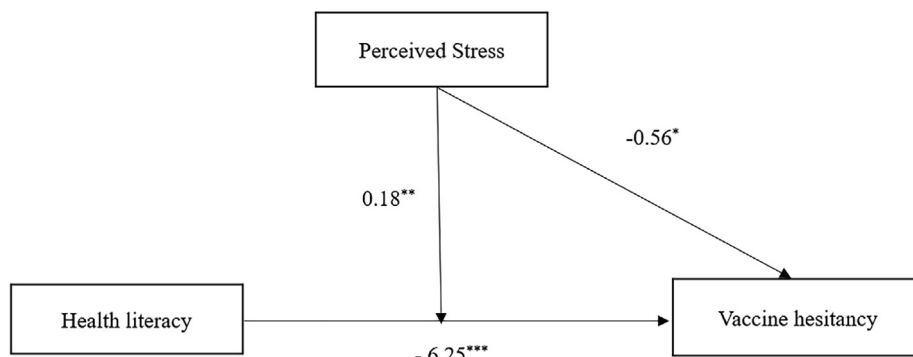
Fig. 1. The moderation model of health literacy and perceived stress predicting vaccine hesitancy. "*": $P < 0.05$; "**": $P < 0.01$; "***": $P < 0.001$.

countries (e.g., 20%) [49], probably because the threat of vaccine-preventable infectious disease is more salient, and people's perceived value of vaccine is higher [8].This may also help explain the differences in vaccine hesitancy between different demographic groups. In our results, it was also found that older age was associated with lower vaccine hesitancy, which was consistent with the previous findings [48,50,51], and a recent systematic review [52] has suggested that young people's high vaccine hesitancy probably because they paid limited attention in vaccination or disease, and their attitude is more subjective to other's (e.g., peers) recommendation (e.g., [53]). In contrast, according to the preliminary findings of our focus group with older adults, their willingness to take vaccine might be driven by the trust in health professionals and authorities. The gender differences is also consistent with previous studies [54–56] that women tended to be more hesitant due to the concerns about the vaccine effectiveness and the fear of injection [57]. Besides, when and where the data is collected may lead to different conclusions on the prevalence of vac-

cine hesitancy [58], as people's vaccine attitude kept changing across different stages of the pandemic. For example, with two waves of data collection in Italy, Palamenghi et al., (2020) found that people's willingness to take vaccine against COVID-19 decreased over time, and was closely related with the trust in vaccines and vaccine research [59]. In contrast, a more recent longitudinal study in Australia reported increased willingness to be vaccinated among the public [60]. Therefore, when generalizing our findings to other populations, contextual and demographic factors should also be taken into account.

More importantly, our findings showed that health literacy is associated with reduced vaccine hesitancy, which was consistent with the findings of Dodd et al., (2021) [61]. Individuals' health literacy, lifestyle and behaviors also contribute to the attitude toward COVID-19 vaccine, which has been relatively overlooked in prior research[52]. On the one hand, health literacy may help individuals understand and assess the effectiveness of the COVID-19 vaccine, thereby increasing their self-efficacy when making vaccination

decision [62]. On the other hand, individuals with limited health literacy may be more susceptible to the misinformation about COVID-19 and vaccine in the media, and find it more difficult to make decisions [63]. This may also raise mistrust of the authorities and the vaccination policy, leading to lower willingness to be vaccinated. It is clear that lack of awareness, limited knowledge, combined with the dissemination of inaccurate information about the vaccination, could result in an increased vaccine hesitancy [64]. Besides, health literacy may also affect how individuals make use of health services, including vaccination. For example, in low-income country such as Bangladesh, low education and limited health literacy were found to be closely related with the low level of service utilization and accessibilities among the lay public [65]. Therefore, in increasingly complex societies, health literacy not only include individual factors such as education, knowledge or disease experiences, but also social and cultural factors [66]. The public health delivery system, health literacy surveillance or education system, could all influences individual's health outcome [52]. However, little research on health literacy has looked at how individual capacities interact with contextual factors, which needs more attention in future studies.

Moreover, our findings also showed that the effects of health literacy differed among people with different levels of perceived stress. According to the health belief model, higher stress increases the perceived severity of and susceptibility to infection, thus increasing people's willingness to take vaccines [67]. Also, stress was found to motivate people to adopt more preventive behaviors [68]. Indeed, the main effects of health literacy and stress indicated that both could boosting individuals' intention to take COVID-19 vaccine. In addition, the moderation analysis showed that among individuals with high levels of stress, the effect of health literacy of reducing vaccine hesitancy disappeared. Probably because the perceived stress can trigger greater anxiety about the infection risk and interfere the decision-making process, thus masking the effect of health literacy. A recent review postulated that COVID-19 related stress may result in cognitive dissonance and tension, to reduce which people will try to make sense of the behaviors they need to adhere to [69], i.e., taking COVID-19 vaccine. In other words, although stress and health literacy both showed positive effect on reducing vaccine hesitancy, the mechanism might be different. When the stress level was low or moderate, people are more likely to use knowledge, information, and health services to make decision, while when the stress level was high, people tend to meaning-making of vaccination to reduce the tension.

In fact, the findings of stress in our findings only provided preliminary evidence for the moderators in understanding health literacy and vaccine hesitancy. Nevertheless, there are some limitations that should be acknowledged. First, future studies are warranted to explore the mechanisms underlying the effects of health literacy on vaccination. A recent study has found that both vaccine literacy and ehealth literacy were associated with greater vaccine uptake intention among younger adults in a lower-middle-income country [70], suggesting different types of health literacy should also be investigated in undresting people's vaccine-related attitude and behaviors. Given the important role of contextual factors, it is still inconclusive whether our findings could be transferred to people in different cultures. To answer this question, cross-cultural research on vaccine hesitancy should be designed with including measures on individual factors such as health literacy and stress, as well as contextual factors such as vaccination policy, social norm, and perceived severity of the disease. Second, due to the COVID-19 policy, we could only use online survey and convenience sampling method, and the gender and age distribution of our respondents were uneven, which may lead to unavoidable selection bias. At last, the three items from HLS-EU-Q measuring vaccine-related literacy may not well address peo-

ple's level of vaccine literacy. By now, COVID-19 vaccine literacy measurement has been developed, such as HLVa-IT [71], which provided an important tool for future studies to address the role of vaccine literacy in people's attitude toward vaccination.

5. Conclusion

Our findings have highlighted the effect of health literacy on reducing the COVID-19 vaccine hesitancy, particularly when the stress level is low or moderate. Given that the general level of health literacy has remained low in China, effort should be made to promote the public's health literacy. Cultivating individual's capacity to obtain, evaluate, and apply health information is vital for people to protect themselves by using preventive measures such as taking vaccines [72]. In addition, tailor-made program should be designed for people with different gender and age. For people with high stress, the effect of health literacy on vaccine attitude may become trivial, and specific strategies involving action cues should be developed to promote vaccine uptake and achieve herd immunity.

Data availability statement

All documentary data and literature relevant to the study are publicly available.

Ethical approval

This study was approved by the Jinan University Medical Ethics Committee (JNUKY-2021-004).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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