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A cross-sectional study of gender role adherence, moral disengagement mechanisms and online vulnerability in adolescents

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ABSTRACT

The wide availability of electronic devices accessible to teenagers has enabled them to use the internet to communicate, share, and obtain information. However, the use of the internet and social media has also increased the risk of vulnerability, exposing people, particularly adolescents, to several risks. We collected data from a sample of 366 adolescents (186 females and 180 males) aged 14–20 years (mean age = 17 ± 1.33 years) to investigate the mediating role of moral disengagement (MD) mechanisms in the relationship between gender and online vulnerability. Data were collected in both the inner-city and suburban high schools of Rome (Italy) using the Qualtrics Platform Online. The participants completed a demographic questionnaire, the Online Vulnerability Scale, and the Civic Moral Disengagement Scale. All participants declared that they accessed and used the internet frequently. Using SPSS, the data were checked for outliers, common method bias, and normal distribution; then, correlation and mediation analyses were performed. Based on the correlation results, a mediation analysis was performed using only the displacement of responsibility as a mediator of the gender-online vulnerability link. Age was entered in the mediation model as a covariate. The results showed that girls were more vulnerable online than boys, who in turn used more moral disengagement mechanisms. In addition, moral displacement showed a positive indirect effect on the relationship between gender and online vulnerability. This means that when including the moral displacement in the mediation model boys appeared more exposed to online vulnerability as they probably adopted more immoral behaviors. These results could help to develop interventions to sensitize adolescents on both taking responsibilities for their actions on the Internet. Limitations and future research directions are briefly discussed.

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List of Acronyms

MD	Moral Disengagement
S.D.	Standard Deviation
IRB	Institutional Review Board
ONS	Online Vulnerability Scale
CMDS	Civil Moral Disengagement Scale
AC	Advantageous Comparison
DV	Dehumanization of the Victim
AB	Attribution of Blame
DifR	Diffusion of Responsibility
DC	Distortion of Consequences
DR	Displacement of Responsibility
MJ	Moral Justification
EL	Euphemistic Labelling
BootLLCI	Bootstrap Lower Level of the 95% Confidence Interval
BootULCI	Bootstrap Upper Level of the 95% Confidence Interval
LGBTQ+	Lesbian, Gay, Bisexual, Transgender, Queer (or sometimes Questioning), and others

1. Introduction

The wide availability of electronic devices accessible to adolescents has enabled them to use the Internet to communicate, share, and obtain information [1]. The use of the internet and social media has also increased the risk of vulnerability among adolescents. Schilder et al. [2] identified three types of risks that adolescents can run into when surfing the Internet: (i) *content risk*, when adolescents access dangerous content; (ii) *contact risk,* when adolescents are contacted by third parties proposing potentially threatening activities or communications to them; and (iii) *commercial risk*, when adolescents are approached by organisations that seek to take advantage by exploit them. In addition, when adolescents spend a lot of time on the Internet, they take away from other, more constructive activities. In this vein, Barry et al. [3] showed that adolescents spend approximately 3 h per day on social media. With the advent of the COVID-19 pandemic, the time spent on the Internet has increased exponentially as a function of age:14 h per week in children 6 to 12-year-olds) and 28 h per week in adolescents 16- to 19-year-olds [4,5].

In addition to these risks, the Internet allows adolescents to explore their identities and strengthen social relationships through live chats and online games. The virtual image is an integral part of social media; it allows the creation of an image in a controlled manner, but also exposes teens to the judgment of the online community. For example, in girls, particular attention to the subject of beauty is significantly associated with dissatisfaction with the body, internalisation of the ideal of thinness, and self-objectification [6,7]. Girls use social media to introduce themselves to others, post photos of themselves, and share everyday activities [8]. This means that adolescents may be exposed to cyber-bullying, violence, pornographic material, manipulation, and even extortion [9], all of which can involve online vulnerability. The latter reflects the capacity to experience disadvantages in terms of psychological, reputational, or physical well-being when surfing the Internet [10].

In this study, gender differences in online vulnerability were explored. In addition, the mediating role of moral disengagement (MD) mechanisms in the gender-online vulnerability link was investigated. Bandura [11–13] introduced the concept of MD, which refers to a set of cognitive distortions through which self-regulating mechanisms can be deactivated and moral self-sanctions disengaged. Bandura [13] described eight MD mechanisms, grouped according to whether they address the behavior, the agent, the effects, and the victim. The MD mechanisms are: *distortion of consequences* (e.g., minimizing the behavioral consequences); *diffusion of responsibility* (e.g., invoking that other people behave similarly); *moral justification* (e.g., invoking a repair for an injustice suffered); *advantageous comparison* (e.g., making comparisons with more serious matters); *displacement of responsibility* (e.g., attributing the responsibility to other people); *euphemistic labelling* (e.g., invoking a different meaning of behaviors); *dehumanization* (e.g., denying of the humanness of behaviors); *attribution of blame* (e.g., attempting to construct causal explanations for behaviors). By these mechanisms individuals restructure negative actions into something more socially acceptable, use language to describe behavior less negatively, minimize their responsibility, impute their behavior to authorities, compare their negative conduct with something worse, and feel less guilty by dehumanizing or by blaming the victim, viewing him/her as responsible for his or her suffering [13]. Notably, MD was found positively related not only to aggressive behavior defined in terms of bullying [14] and cyber-bullying [15], but also to cyber victimization [16,17]. This means that MD can represent a keystone to understand a variety of behaviors, including online vulnerability. Therefore, the study of the mediating role of MD in the gender-online vulnerability link in a sample of adolescence allows understanding of the MD mechanisms predictive of online risks faced by boys and girls. Investigating such relationships in adolescence may help in exploring the key role of the Internet in shaping the character. Indeed, given that adolescence represents a turning point in terms of civic engagement, responsibility toward others, and moral reasoning, the understanding of the MD mechanisms that mediate the role of gender in online vulnerability is crucial for developing a moral character.

1.1. Gender differences in online vulnerability

Several studies showed that boys and girls use the Internet differently [18–22], and as a result, they can differently experience online vulnerability. Specifically, boys tend to share personal information on their profiles [23], are more likely to meet up with strangers they have previously met online, are more involved in acts of cyberbullying [24], and play online age-restricted videogames [25]. By contrast, girls' avatars are more sexually explicit than boys' avatars [26,27]. Yet, girls use the Internet more for communication (they message, use blogs and social media, [28]); they also tend to post more photos, whereas boys post more videos. Girls tend to have private profiles on Facebook, while boys tend to have more public profiles [23]. Baumgartner [29] found that girls are involved in online activities requiring unwanted situations. Specifically, girls are more vulnerable to falling victim to online harassment [30]. Jane [31] reported that an increasing number of females experienced gendered cyber-hate. In this vein, Nadim and Fladmoe [32] found that females are more exposed to online harassment directed toward gender than males, whereas males are more exposed to hate speech concerning their opinions. These authors highlighted that the awareness of belonging to a vulnerable group may incite more fear and stronger reactions. Savoia and co-workers [33] suggested the role of social factors that make girls more vulnerable to harassment, violence, and sexual abuse. Michael and Ben-Zur [34] found that boys are more influenced by peers' norms, whereas online risky behavior for girls is more related to the quality of their relationships with their parents. Thus, gender differences in online risky behavior should be related to the socio-educational level of the family and the cultural context, parenting style, as well as socialization strategies that families offer to their children [21,35,36]. Notten and Niken [21] found that part of online risky behavior depends on the adolescent's personality traits (i.e., level of sensation seeking related to Internet use). Moreover, they also found less risk of online participation by adolescents who lived in more digitalized societies with higher levels of Internet use.

1.2. Gender differences in moral disengagement

Boys and girls probably do not use the same MD mechanisms, partially because they have different roles in aggressive behaviors. For example, boys are more often involved in direct aggressive behaviors, while girls are more often involved in indirect ones (e.g., spreading gossip about the victim or excluding them from groups) [37]. However, some findings showed contrasting results [38]. Kokkinos and colleagues [39] found a positive association between MD and different forms of aggression in boys, whereas Bussey et al. [40] showed that no effect of gender was associated with MD mechanisms in cyber-bullying. Interestingly, Pepler et al. [41] suggested that females are less engaged in aggression toward others, even when they have high levels of MD tendencies, probably because of better emotion regulation and emotion display than boys. Bjärehed et al. [42] found that all the mechanisms of MD were significantly correlated with direct and indirect bullying among girls, but not among boys. The authors interpreted their findings as referring to gender norms. Specifically, girls grow to be more compliant, subordinate, and gentle, whereas boys grow to be more dominant, competitive, and aggressive [43]. In this vein, society considers aggression perpetrated by males more acceptable than aggression perpetrated by females, and this would explain why girls produce more MD mechanisms to avoid guilt when they engage in aggressive behaviors. Anyway, the dangers of the Internet and the risks teenagers face online go beyond direct and indirect cyberbullying incidents. Teens may be contacted by strangers, may receive material that makes them uncomfortable, and may be pressurized and asked to share intimate photos and personal information [33]. Given this evidence, it is clear that the study of the relationship between gender and moral disengagement deserves more attention.

1.3. Moral disengagement and online vulnerability

The study of the relationship between MD and online vulnerability is scattered to date but can be explored considering that people, and in particular adolescents, are victims of negative online experiences, including for example cyber victimization. This latter refers to people who receive cyber aggression by technology [44]. Notably, MD was found more related to cyber-bullying [45], which involves intentional and repeated harm inflicted by the technology [44]. Indeed, the distance from the online victims facilitates the disengagement from the emotional consequences of harmful actions, especially in terms of moral justification, euphemistic labeling, and advantageous comparison [46,47]. In addition, cyber aggressors tend to perceive their behavior as a joke [48] and may distort the consequences by believing that their victims are not experiencing negative effects [42]. Cybercrimes extends also to violations of privacy. D'Arcy et al. [49] demonstrated that the MD of employees significantly predicted internet attacks and violations of organizational privacy. More importantly for the present study, previous research showed that also cyber victimization or cyber-bullying/victimization are characterized by high levels of moral disengagement through technology [16]. Renati et al. [50] also found that cyberbullying/victimization showed significantly higher levels of overall moral disengagement. These findings extend to the cyber context the view that MD can positively correlate to victimization [51], and open to the idea that MD and online vulnerability are strictly related. In this vein, the association between moral disengagement and vulnerability, understood as victimization (the injured party), probably depends on the overlap between perpetration and victimization, given that aggressor, who are morally disengaged, were often victimized in the past [52].

2. Hypotheses

The present study aimed to study the mediation of MD mechanisms in the relationship between gender and online vulnerability. The hypotheses were formulated as follows:

1) girls show higher online vulnerability than boys.
2) MD mechanisms partially mediate the relationship between gender and online vulnerability.

3. Method

3.1. Participants

Adolescents were enrolled by schools, which were required to be located within the city of Rome (both inner and suburban) and to include adolescents aged 14–20 years. Schools were invited to participate in the study by e-mail or telephone, through simple sampling. Schools were informed about the aim of the study (an educational initiative designed to reduce hate and risky online behaviors) and were requested to provide their availability by sending a message to researchers. A meeting in presence was also organized with those schools that accepted to participate in the study in order to discuss the theoretical and procedural aspects of the study with the schools' authorities. In total 24 schools were contacted. 16 schools agreed to participate in the study, whereas 8 schools declined participation.

The sample size was determined using G*Power 3.1 [53]. To perform a mediation analysis, considering 10 predictors (e.g., gender as the focal predictor, 8 moral disengagement mechanisms as mediators, and age as the covariate), the effect size f2 = 0.15 - medium magnitude, alpha = 0.001, and power = 0.95, the suggested sample size was of 281 participants at least. In the present study, 366 adolescents were enrolled: 186 were female (50.8%) and 180 were male (49.2%). The average age was 17 years.; S.D. = 1.33 years. The age range was 14–20 years. The sample was equal for the opportunity to access or frequency of Internet use. The Institutional Review Board (IRB, Department of Psychology, Sapienza University of Rome, Italy; protocol number 1450/2021) approved this survey following the Declaration of Helsinki.

3.2. Procedure

Data were collected in both inner city and suburban high schools of Rome (Italy) to balance any socio-economic differences in the sample. Although participants were not specifically asked to indicate the household income bracket, the economic distribution in Rome includes fewer conditions of socio-economic risk in inner high schools than in suburban ones. For such a reason, we balanced the number of schools in inner and suburban districts. Participants aged 18–20 years old signed the written informed consent by themselves, whereas for participants aged 14–17 years old, the parents signed the consent to participate in the study. Participants were free to withdraw from the study at any time. Firstly, a short demographic questionnaire was administered (e.g., age, sex, use, and frequency of the Internet), and then adolescents filled in some questionnaires (see Instruments below) through the Qualtrics Platform online survey. Participants filled in the online survey at school using computers. They were instructed to click on the link provided by the experimenters and to respond to the questions according to the instructions displayed. The order of the test administration was randomized across participants. The entire administration lasted about 20 min.

3.3. Materials

3.3.1. Online Vulnerability Scale

The Online Vulnerability Scale (ONS) explores how often people personally experience or see others encountering situations or content of a violent, embarrassing, harmful, or unwanted nature when using social networks. It consists of 6 items rated on a 5-point Likert scale ranging from 1 (Very rarely) to 5 (Very often). The scale was translated following the English version developed by Buglass and colleagues [54]. In this study, the scale showed a Cronbach's alpha of .803. Higher scores indicate greater exposure to online vulnerability.

3.3.2. Civic Moral Disengagement Scale

This scale measures the Civil Moral Disengagement Scale (CMDS) which was introduced by Bandura [12] to describe the psychosocial mechanisms by which individuals mitigate the moral consequences of their harmful behavior to self-justify violations of civic duties and obligations. This scale consists of 32 items rated on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). This scale measures the following 8 mechanisms of MD: Advantageous comparison (AC), dehumanization of the victim (DV), attribution of blame (AB), diffusion of responsibility (DifR), distortion of consequences (DC), displacement of responsibility (DR), moral justification (MJ), and euphemistic labelling (EL). In this study, the Italian version developed by Caprara et al. [55], was used, and the internal consistency of the global index indicated good psychometrics properties with a Cronbach's alpha value of 0.912. Regarding the 8 mechanisms, Cronbach's alphas ranged from 0.470 to 0.680.

3.4. Statistical analyses

A cross-sectional study was carried out in order to explore the extent to which the relationship between gender and online vulnerability was mediated by moral disengagement mechanisms. At the aim, a mediation model was defined considering gender (boys = 1; vs girls = 0) as a focal predictor (x), online vulnerability as outcome (y), and moral disengagements as mediators (e.g., AC, DV, AB, DifR, DC, DR, MJ, and EL) (M). Before running the mediation analysis, data were checked for outliers; then single-factor test was performed to check the common method bias (CMB); data were also checked for normal distribution before running a correlation

analysis. Thus, the moral disengagement mechanisms and the covariate age were entered in the mediation model on the basis of the correlation analysis.

4. Results

To determine the outliers, given that the sampling size was larger than 100, z-scores in the range between −4.0 and + 4.0 was taken as the reference value [56]. No case was found to have a z-score out of the range −4 and +4, thus, no outlier was detected.

To verify the common method bias (CMB), Harman's single-factor test [57] was carried out. All variables of the study were used in order to check the variance explained by a single-factor exploratory model. The single factor explained 40.93% of the variance, revealing no CBM problems (test critical threshold is ≥ 50%).

Preliminary analyses performed on online vulnerability and moral disengagement global index revealed that the two measures were not normally distributed (Kolmogorov-Smirnov Test: Z-online vulnerability = 0.066, $p < .01$; Z-moral disengagement = 0.054, $p < .05$). We further verified the normal distribution of the 8 subscales concerning MD mechanisms and we found that all measures were not normally distributed: Kolmogorov-Smirnov Test ranging from = 0.076; $p < .0001$ to .180 $p < .0001$. Therefore, Spearman's Rho correlation analysis was performed. Means, standard deviations, and correlational analysis are shown in Table 1.

The correlation analysis showed that girls are more vulnerable than boys, which in turn revealed higher scores in the most of MD mechanisms than girls (except in AC and AB). Age positively correlated to online vulnerability and to DR. Based on the correlation analysis, given that only DR was positively related to both gender and online vulnerability, only DR was used as a mediator (M) of the relationship between gender (x) and online vulnerability (y). Age was also entered in the mediation model as covariate. The PROCESS macro for SPSS, version 3.5 [58] was used. 5000 bootstrap samples were used. Bootstrapping is a non-parametric method, which allows bypassing the non-normality distribution issue, testing the indirect effect [59], even in small samples [60].

The Mediation analysis showed that the direct effect of gender on online vulnerability was significant (ß = −.332; $p < .001$): girls showed higher online vulnerability than boys. In addition, gender was positively related to DR (ß = 0.188; $p < .01$) meaning that boys showed higher scores in DR than girls; and DR was positively related to online vulnerability (ß = 0.166; $p < .05$) showing that the higher DR the higher online vulnerability (see Fig. 1). Finally, the indirect effect of DR was positively significant (ß = 0.031, 95%, BootLLCI = 0.0028 - BootULCI = 0.0752). The covariate Age affected positively online vulnerability (ß = −0.083, $p < .05$).

5. Discussion

The present study investigated in a large sample of adolescents the mediating role of the MD mechanisms in the relationship between gender and online vulnerability. In line with the first hypothesis, girls showed higher online vulnerability than boys. This is compatible with the evidence that girls tend more than boys to post personal photos and share personal events on social media [23,28]. They are also more sensitive than boys to content about their outward appearance. Some studies showed that girls are more prone than boys to harassment, sexual abuse, and online hate-speech concerning their appearance and the fact that they belong to the female gender, often messages of hatred are about gender and the social role that women have [31]. Therefore, technology and online opportunities may enhance gender-based violence consisting of stalking, harassment, cyber-bullying, and unsolicited pornography. Girls are often particularly targeted, especially if they are politically outspoken, belong to a minority, identify as LGBTQ+, or have a disability.

On the other hand, boys showed higher scores in most of MD mechanisms than girls. One possible interpretation of this finding is that boys more than girls take online risk-taking attitudes; according to some authors, this propensity would also be linked to personality traits, such as sensation-seeking [21,61] that would be typical of the age studied in this work. We assume that in our sample, boys tend to be more morally disengaged to justify actions performed online that they know are reprehensible. Data on higher use of

Table 1
Means, standard deviation (S.D.), and inter-correlations (Spearman's Rho).

	Means(S.D.)	Gender	Age	Online Vul.	MD_GI	MJ	EL	AC	DR	DifR	DC	AB	
Gender		1											
Age (years)	17(1.33)	.070	1										
Online Vul.	2.53(.84)	−.158**	.112*	1									
MD_GI	2.09(.58)	.214**	.064	.058	1								
MJ	2.25 (.08)	.284**	.060	.041	.801**	1							
EL	2.01 (.69)	.182**	.090	.040	.755**	.533**	1						
AC	1.79 (.74)	.059	.072	.035	.848**	.600**	.616**	1					
DR	1.95 (.66)	.132*	.130*	.106*	.748**	.530**	.520**	.552**	1				
DifR	2.27 (.82)	.275**	.011	.072	.804**	.656**	.570**	.556**	.557**	1			
DC	2.35 (.75)	.128*	−.013	.034	.736**	.568**	.482**	.487**	.562**	.520**	1		
AB	2.48 (.81)	.058	.065	.068	.724**	.483**	.494**	.595**	.476**	.497**	.406**	1	
DV	1.62 (.62)	.184**	.005	−.017	.721**	.513**	.523**	.585**	.461**	.519**	.518**	.460**	1

Note: **$p < .01$ (two tailed); *$p < .05$ (two tailed); N = 366
Legend: Online Vul. = online vulnerability; MD_GI = moral disengagement global index; MJ = moral justification; EL = euphemistic labelling; AC = advantageous comparison; DR = displacement of responsibility; DifR = diffusion of responsibility; DC = distortion of consequences; AB = attribution of blame; DV = dehumanization of the victim

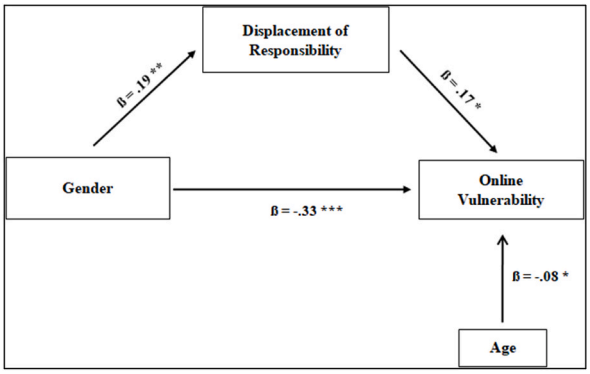

Fig. 1. Mediation model - Note: * = p < .05; ** = p < .01; *** = p < .001.

MD in boys than in girls are not completely new in the literature [62–64] and seem also in line with the social roles and educational styles boys and girls received at home.

Interestingly, among the MD mechanisms, only the DR was related to online vulnerability. Then, we observed the indirect effect of DR on the relationship between gender and online vulnerability. This indirect effect contradicts the fact that girls are more vulnerable online since they use fewer MD mechanisms. At a closer glance, males can become more vulnerable than females since they use the DR mechanism. In other words, boys have a higher global MD index than girls, and the mechanism of DR mediates the relationship between gender and online vulnerability.

Another aspect that deserves an interpretation is the lack of the mediation role of the other MD mechanisms. Notably, MDs involved in online and offline behavior are different. This observation also emerges in the comparison between bullying and cyberbullying, in which different MDs intervene. According to Runions and colleagues [65,66] cyberbullying is characterized by profitable comparison and shifting of responsibility. Therefore, given that in the present work only online vulnerability was considered, it is not surprising only the effect of DR.

Despite the finding that the girls' group showed lower scores in MD mechanisms, literature reported that girls adopt more maladaptive strategies than boys. Girls often blame themselves for posting intimate photos under pressure from a stranger or ruminate or catastrophize the consequences of an action or a comment received. In this respect, both girls and boys who definitely use different DM mechanisms and moral feelings are more vulnerable online than girls and boys who do not use such responses. It is important to bear in mind that for adolescents the line between online and offline life is very thin, as is the line between joking and offending [67]. The accessibility of electronic devices has transferred aggressive behavior into the meta-world, and along with this behavior has also transferred mechanisms to alleviate guilt and to justify aberrant behavior in one's own eyes. It must also be considered that although there is a parallelism between the virtual and real worlds, online behavior is more disinhibited than offline behavior, this may facilitate the neglect of one's moral code [68]. The greater distance from the victim produces an increase in minimizing behavior by adopting the MD mechanisms [64].

Our results can also be interpreted in an alternative way, it is possible that boys perceive less responsibility for their online actions by implementing the mechanism of DR, while girls have a greater awareness of their actions and tend to interpret the outcomes as related to their actions (e.g., blaming herself for having not been far-sighted in posting images that were later used against them). For this reason, the results initially appear in contradiction showing a dual vulnerability. However, it is important to note that in girls' online vulnerability is related to the use of the Internet, whereas in boys to the use of MD mechanisms, specifically DR. Yet, it is noteworthy that breaking a rule challenges the view that the offender has of him/herself by developing several conflicting thoughts, transforming justifications in firm beliefs, which contribute to reiterate the offence [69].

Another finding that emerges is that as age increases also online vulnerability increases. This is in line with the evidence that cybercrime behavior increases as age increases [45,70,71]. A possible interpretation of this result could be related to parental control over children's use of the Internet, which decreases as a function of age. Moreover, as age increases, the freedom that young people enjoy also increases, and this exposes them more to the risks of meeting strangers whom they have chatted online with. Nevertheless, some studies found differences in online vulnerability related to age among girls and boys. Girls aged 11–13 experienced a negative association between social media and life satisfaction compared with boys – who experience this at 14–15 [72]. We could not observe this trend because our sample includes only boys and girls 14–20 years old. Life satisfaction can drive increased internet and social media use – creating a negative cycle. Undoubtedly, the pandemic period has brought boys and girls to increase their virtual life.

5.1. Limitations and future directions

One of the limitations of the present study is that it was based on self-reports. Although the CMB was not found, future studies should consider performance tasks to measure MD mechanisms and online vulnerability, for example considering the actual disclosure of personal information, which is one of the aspects that is most compromised in online vulnerability. Using performance task probably would also solve the issue of the small effect size of the indirect effect of DR. Furthermore, the cross-sectional nature of the design does

not allow to define of causal inferences in terms of development. Future studies should consider a longitudinal perspective. Finally, data were collected during the COVID-19 pandemic, a condition that has certainly increased the use of electronic devices, which have somehow become the only means for young people to stay in touch with others. It would be interesting to extend these results to other variables, such as personality traits, and emotional processes.

6. Conclusions

Summing up, the mediation effect of DR on the relationship between gender and online vulnerability suggests that boys tend to be more morally disengaged to justify their online actions that they know. This suggests not using a global MD index, but to consider specific mechanisms of MD. This result could be also explained by the social roles and educational styles that boys and girls received at home. This is consistent with the view that as age increases also online vulnerability increases, probably as a consequence of a decrease in the parental control over boys' and girls' use of the Internet. In conclusion, these findings could help to identify protective factors to reduce the risk of becoming a victim online, as well as to organize and develop intervention programs to sensitize adolescents to take responsibility for their actions and the effects these actions can have on other people.

Author contribution statement

Laura Piccardi; Massimiliano Palmiero: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jessica Burrai; Alessandro Quaglieri; Giulia Lausi; Emanuela Mari: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Pierluigi Cordellieri: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Angelo Fraschetti: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Anna Maria Giannini: Conceived and designed the experiments; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

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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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