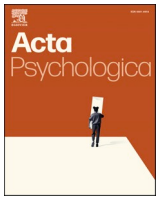
Acta Psychologica 261 (2025) 105886

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy



Social isolation impacts risk perception but not peer influence in mid-adolescence

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ARTICLE INFO

Keywords:
Social isolation
Loneliness
Peer influence
Risk perception
Adolescence

ABSTRACT

Adolescence is a period of increased sensitivity to the social world, when social connection becomes particularly important and peer influence is heightened, especially in the context of risky decision-making. Here, we investigated whether peer influence and risk perception are affected following an absence of social interaction. In an experimental within-participants design, 40 participants aged 16–19 completed short-term isolation with and without access to virtual social interactions, and a non-isolated baseline, and completed a task that measured risk perception and susceptibility to peer influence. The results demonstrated that, first, while participants showed significant peer influence in all sessions, this was not affected by isolation. Second, after complete isolation, participants perceived situations as less risky, compared to isolation with virtual interactions. These findings indicate that isolation affects adolescents' perception of risk, which might have implications for risk-taking when social connection is lacking.

1. Introduction

1.1. Social isolation and loneliness

Social isolation and loneliness are significant contemporary global challenges. Though precise terminology may vary, social isolation is defined here as the objective state of being alone, while loneliness is defined as the subjective distressing feeling that results from unmet social needs (Cacioppo & Cacioppo, 2018; Ortiz-Ospina & Roser, 2024). Both forms of social disconnection have been increasing in prevalence over time (Buecker et al., 2021; Kannan & Veazie, 2023); a trend that worsened during the COVID-19 pandemic (Ernst et al., 2022; Lee et al., 2020). In May 2023, the US Surgeon General declared loneliness a public health crisis (US Office of the Surgeon General, 2023), highlighting the substantial concerns around the consequences of social disconnection.

Loneliness has been linked to negative health outcomes, such as poorer mental health and wellbeing (Lee et al., 2020; Nuyen et al., 2020; Park et al., 2020; Wang et al., 2018), as well as adverse physical health outcomes and mortality (Holt-Lunstad et al., 2015; Leigh-Hunt et al., 2017; Rico-Uribe et al., 2018). Beyond health, social isolation and loneliness have also been linked to poorer cognition (Boss et al., 2015; Yin et al., 2019). Understanding the psychosocial and health consequences of social isolation and loneliness is crucial, particularly in light of evidence of the growing trend towards both.

1.2. Social isolation and loneliness in adolescence

Adolescence (age 10–24 years; Sawyer et al., 2018) is a period of life when there is increased social need (Tomova et al., 2021), and therefore adolescents might be particularly vulnerable to feelings of loneliness and interpersonal disconnection. Recent studies have indicated that adolescents report the highest levels of loneliness across all age groups (Barreto et al., 2021; Shovestul et al., 2020; Twenge et al., 2021, but see Mund et al., 2020), and this tendency has been steadily increasing, with a particularly sharp increase over the past 15 years (Buecker et al., 2021; Twenge et al., 2019; Twenge et al., 2021).

The negative outcomes associated with loneliness may be especially

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https://doi.org/10.1016/j.actpsy.2025.105886
Received 4 March 2025; Received in revised form 22 October 2025; Accepted 29 October 2025
Available online 13 November 2025

deleterious during adolescence as this is considered a sensitive period of development in which social integration and a sense of belonging is of particular importance (Blakemore & Mills, 2014; Blum et al., 2022; Tomova et al., 2021). For instance, adolescents show hypersensitivity to peer rejection (Sebastian et al., 2010) and to social approval (Foulkes & Blakemore, 2016). Social connections with peers during this stage of life can predict adolescent psychosocial functioning (van Harmelen et al., 2017) and are associated with social brain development (Becht et al., 2021).

1.3. Peer influence and risk in adolescence

Adolescence is also a time often characterised by a heightened propensity to take risks, such as dangerous driving, binge drinking and smoking (Steinberg, 2008). Risk-taking is broadly defined as an action in which the outcome is uncertain, with the possibility of both positive and negative consequences (Hertwig et al., 2018). Both experimental studies and real-world data demonstrate a greater propensity to take risks in adolescence and emerging adulthood (Defoe et al., 2015; Duell et al., 2018; Willoughby et al., 2021).

A related concept is risk perception, which is defined as the extent to which one perceives a given activity as having the potential for adverse consequences (Galvan et al., 2007). Evidence indicates a link between risk perception and risk-taking behaviour (Sheeran et al., 2014; Sitkin & Weingart, 1995; Weber et al., 2002). For instance, a 10-year longitudinal study reported that shifts in perceived risk during adolescence predicted later substance use (Grevenstein et al., 2015). Understanding risk perception is important as it reflects the cognitive and social mechanisms that may underlie an adolescent's decision to engage in, or refrain from, risky behaviour.

There is a substantial body of evidence indicating that adolescents are more likely to take risks while in the presence of others, in particular peers, compared to when alone (Chein et al., 2011; Gardner & Steinberg, 2005; Powers et al., 2022). This social influence effect even occurs without direct peer observation, for instance, simply being informed about peer group norms can alter adolescents' perception of risk (Knoll et al., 2015, 2017).

While this social influence effect on decision-making is present at all ages, it is strongest during late childhood and early adolescence (~8–14 years old) (Chierchia et al., 2020; Foulkes et al., 2018; Gardner & Steinberg, 2005; Knoll et al., 2015, 2017). Furthermore, young adolescents' perception of risk appears to be more influenced by teenagers (than by adults), while children and adults are more influenced by adults than by teenagers (Knoll et al., 2015, 2017; Reiter et al., 2019). This underscores the role that peer norms play in shaping decision-making during adolescence.

The heightened susceptibility to social influence in adolescence is often portrayed negatively, however, the outcomes are not exclusively detrimental. Peers can promote cautious decision-making (Osmont et al., 2021; Tomova & Pessoa, 2018) and adolescents demonstrate increased sensitivity to peer influence in contexts involving positive outcomes such as prosocial behaviour and anti-bullying campaigns in schools (Ahmed et al., 2020; Chierchia et al., 2020; Foulkes et al., 2018; Paluck et al., 2016; Sullivan et al., 2022; van Hoorn et al., 2016).

This pattern of peer conformity across a variety of contexts suggests that heightened susceptibility to peer influence might serve a socially adaptive purpose. It has been proposed that conformity to peer group norms may facilitate integration, cohesion and acceptance within a social group (Laursen & Veenstra, 2021; Reiter et al., 2019). One study found that heightened susceptibility to peer influence in adolescence predicted improvements in the quality of peer relationships 1.5 years later, suggesting that being responsive to peer preferences may lead to adaptive social functioning (Reiter et al., 2021).

1.4. Social exclusion in adolescence

The avoidance of social risk, that is, avoiding exclusion or rejection by a peer group, has been proposed to contribute to the heightened peer influence effect in adolescence (Blakemore, 2018; Blakemore & Mills, 2014). Social exclusion refers to a rejection or an ostracising act by the social group (Tomova et al., 2021), which is similar to but distinct from social isolation, as it includes an active exclusion by others. This can be manipulated in the laboratory. For example, the Cyberball paradigm involves a computerised ball-tossing game between the participant and two virtual players (confederates), and participants can be included or excluded by the other players (Williams et al., 2000). Adolescents show increased sensitivity to the negative outcomes of social exclusion in Cyberball, compared with adults (Fuhrmann et al., 2019; Pharo et al., 2011; Sebastian et al., 2010). It has been proposed that, in order to avoid these aversive feelings, adolescents may be especially motivated to conform to peer norms and behaviours, even when those behaviours involve physical, legal or reputational risks (Blakemore, 2018). This can lead to increased peer influence on risk-taking because adolescents may engage in risky behaviours in order to avoid the social risk of exclusion or rejection by their peer group.

Social exclusion has been linked to both increased peer influence and greater engagement in risk-taking behaviours (Duclos et al., 2013; Meng, 2020; Williams et al., 2000). For example, participants aged 14–16 who reported lower resistance to peer influence engaged in greater risky decision-making after experiencing social exclusion, compared to adolescents with higher resistance to peer influence (Peake et al., 2013). Neural responses to social exclusion have been found to predict subsequent risk-taking in the presence of peers (Falk et al., 2014; Wasylyshyn et al., 2018). Together, these findings suggest that social exclusion can increase adolescents' vulnerability to peer influence, thereby promoting risk-taking behaviour.

While the experience of social isolation is different from social exclusion, they both involve deprivation of social connection, and therefore, might have other similar cognitive and behavioural consequences. It has been proposed that social connection is a fundamental basic need and that loneliness signals an absence of this, which serves to motivate a behavioural response to remedy it (Cacioppo et al., 2014). Therefore, both social exclusion and social isolation may increase susceptibility to peer influence and increase risk-taking as a means to improve peer relations or regain social connection (see Tomova et al., 2021).

1.5. The role of social media

An important factor to consider regarding the impact of isolation and loneliness in adolescence is the online social world. The growing prevalence of social disconnection has coincided with the rapid rise in the use of digital technology enabling virtual social interactions, most notably, social media (Ortiz-Ospina, 2019). As well as reporting high levels of loneliness, adolescents also report the highest levels of social media use (Bayindir & Paisley, 2019; Hruska & Maresova, 2020), leading some to argue that spending more time using digital media has contributed to increases in loneliness due to a displacement of in-person socialising (displacement hypothesis; Kraut et al., 1998; Nie, 2001; Nie & Hillygus, 2002; Twenge et al., 2018). On the other hand, it has been argued that using digital media can enhance wellbeing via increased virtual social interactions (Lin et al., 2016; Valkenburg et al., 2022; Valkenburg & Peter, 2007). The complexity of this debate highlights the importance of understanding the role virtual social interactions play in mitigating, or possibly exacerbating, the effects of social isolation and loneliness.

1.6. The current study

In this study, we aimed to investigate the effects of acute social

isolation on risk perception and susceptibility to peer influence in adolescents aged 16–19 years. We extended the experimental design used in Tomova et al. (2020) by adding an additional condition to disentangle the impact of virtual and in-person interactions. We used a within-participant experimental design in which participants were isolated for 3.5–4 h across a total of three sessions taking place on separate days. Differences in risk perception and susceptibility to peer influence after isolation, compared to a non-isolated baseline condition, were assessed. Participants completed a baseline session followed by two counterbalanced isolation sessions. One isolation session involved total isolation from in-person and virtual interactions (iso-total), and in the other isolation session, participants had access to virtual interactions only (iso-with-media). Following isolation, participants completed a task that assessed susceptibility to peer influence on risk perception (adapted from Knoll et al., 2015). Risk perception was assessed by asking participants to rate the perceived level of risk associated with various situations, while peer influence was operationalised by measuring the likelihood and extent to which participants adjusted their risk ratings after being presented with the average rating of other young people. The experimental design allows inferences of causality in terms of the effects of social isolation on mood, cognition and behaviour.

The current study sought to investigate the following key research questions:

1. Does social isolation alter adolescents' risk perception?
2. Does social isolation heighten peer influence on risk perception, whereby isolated individuals seek social reintegration through conformity to peer opinions?
3. Does access to virtual social interactions mitigate any isolation effects, potentially serving as a buffer against loneliness?

We tested the following pre-registered confirmatory hypotheses (https://osf.io/kbgsv):

1. Isolation (iso-with-media and iso-total) will increase susceptibility to peer influence on risk perception.
2. Virtual social interactions during isolation (iso-with-media) will remediate the effects of isolation on susceptibility to peer influence on risk perception.

We additionally tested the following hypothesis (derived after publishing the pre-registration):

3. Risk perception will be affected by social isolation.

2. Methods

2.1. Participants

This study was part of a larger project for which methods are described elsewhere (Tomova et al., 2025; Towner et al., 2024). An a priori power analysis revealed that 38 participants were required to detect medium size effects (Cohen's $d = 0.47$; power = 0.8, alpha = 0.05) for the within-participant effect of the experimental manipulation on loneliness (calculated from a subset of data from 18 to 24-year-olds in Tomova et al., 2020). We recruited 42 adolescents; two participants did not complete all sessions and so were not included in analyses, leaving a final sample of 40 adolescents between the ages of 16–19 years ($M_{age} = 17.1$, $SD = 0.9$; 22 female, 18 male). Data collection ended when 40 participants had completed all three sessions. Participants were recruited through local schools, online advertisements and flyers in Cambridgeshire. Adolescents were invited to participate if they were aged between 16 and 19 years, were fluent English speakers, and did not have any current diagnosed neurological or psychiatric conditions. This was part of a larger study that involved an MRI scan and so participants were screened using standard MRI eligibility criteria (i.e., no permanently implanted metal in their body). As data collection occurred during the COVID-19 pandemic and lockdown measures, participants were additionally assessed by a COVID-19 health screening form. Participants were only included if they were classified as low risk according to the guidance set out by the Department of Psychology at the time of screening. This involved excluding people who currently had COVID-19 or symptoms, chronic health conditions (e.g., asthma) and those who smoked.

Following the methods of Tomova et al. (2020), we were interested in studying the effects of isolation in socially well-connected adolescents and therefore we additionally excluded those who: lived alone; reported high levels of loneliness (scoring >50 on the UCLA Loneliness scale, which is 1 standard deviation above reported mean loneliness levels for students [Russell, 1996]); and/or reported low social connectedness. This was measured by asking participants to indicate the number of people that they interacted with on a purely social basis over the past 30 days (adapted from Lewis et al., 2011) and their number of close friends (Norbeck et al., 1981). Those reporting fewer than 10 social interactions and/or fewer than two close friends were excluded (both cut-offs are ~7 standard deviations below previously reported means for adolescents [see Von Der Heide et al., 2014]). We lowered these exclusion thresholds for social connectedness compared with previous studies (e.g., Tomova et al., 2020) as reduced socialising was expected due to COVID-19 social distancing regulations.

This study was approved by the Cambridge Psychology Research Ethics Committee (PRE.2020.088). Informed consent was obtained from all participants, and from parents of participants under 18 years. The task, methods and hypotheses in this study were pre-registered (https://osf.io/kbgsv). Data collection took place between April 2021 and February 2022. All data, code and the pre-registration are publicly available on the Open Science Framework.

2.2. Procedure

2.2.1. Experimental sessions

Participants completed three separate sessions with the number of days between sessions ranging from 2 to 125 ($M = 32.5$, $SD = 27.51$). Days between sessions was included in a sensitivity analysis (see *Supplementary Materials*). At baseline, a series of questionnaires was followed by behavioural tasks. Baseline was completed first to ensure comparison of the two types of isolation with a condition that was unaffected by the experience of isolation.

Following baseline, each participant underwent two further sessions: iso-with-media (isolation with access to virtual social interactions only) and iso-total (total isolation from both in-person and virtual social interactions). The order of isolation sessions was counterbalanced across participants. Each session was completed in a comfortable room at the Department of Psychology, University of Cambridge, UK. The room included a computer, desk, armchair, stocked fridge, puzzles and games, as well as a skylight window, and had access to a bathroom.

Participants were informed that the isolation period would last between 3 and 4 h but were not informed of the precise end time in order to prevent expectation effects. The actual duration of the isolation period was randomised between 3.5 and 4 h in increments of 5 min ($M_{\text{iso-with-media}}$ = 3 h 47 mins, $SD = 10.0$ mins; $M_{\text{iso-total}}$ = 3 h 46 mins, $SD = 11.2$ mins; $t(39) = 0.30$, $p = .765$).

The **iso-total** session involved participants spending between 3.5 and 4 h alone, with no access to in-person or virtual interactions. Before this session, participants handed their electronic devices over to the researcher (including phones, laptops, tablets etc.). They were asked to engage in non-social activities only, not to sleep and were encouraged to bring in any suitable and enjoyable activities to prevent boredom. For instance, participants brought nail varnish, art materials and school homework. To minimise interactions with experimenters, participants received comprehensive instructions on the session procedures and behavioural tasks. Access to the messaging app, Slack, was also enabled

on the computer in the room so that participants could contact the experimenter in case of troubleshooting issues or emergencies. A Local Area Network camera streamed the video (no audio) to the experimenter's laptop throughout the isolation sessions. It was emphasised to participants that this was to periodically check their safety and was not continuously monitored or recorded.

The **iso-with-media** session was identical except that virtual social interactions were allowed. Participants were able to use their own devices (such as their phones, laptops, tablets etc.) as well as the computer in the room and were encouraged to engage in activities they enjoy. Including this session allowed us to investigate whether access to virtual social interactions remediated any impact of isolation on susceptibility to peer influence or risk perception. While in-person interactions are not possible, engaging in virtual social interactions may fulfil certain social needs which may reduce any effects of isolation on emotion, cognition and social behaviour (Lin et al., 2016; Valkenburg et al., 2022; Valkenburg & Peter, 2007).

2.2.2. *Questionnaires and behavioural tasks*

During the baseline session, participants firstly reported on state measures including momentary loneliness, social activity craving (how much they wanted to engage in social activity) and boredom, on a sliding scale (0−100), as well as mood (Positive and Negative Affect Scale [PANAS]; Watson et al., 1988). Following this, participants completed questions assessing depression (Center for Epidemiological Studies Depression Scale [CES-D]; Radloff, 1977), substance use and craving (urge to drink alcohol or vape if the participant indicated that they engage in these behaviours at least once per month), as well as state and trait anxiety (State and Trait Anxiety Inventory [STAI-state and STAI-trait]; Spielberger, 1983). Participants finished the baseline session by completing a non-verbal reasoning task (Matrix Reasoning Item Bank [MaRs-IB]; Chierchia et al., 2019). Trait-level variables were included in exploratory analyses to understand whether they moderated any effect of isolation on peer influence susceptibility or risk perception.

The aim of the isolation period was to induce temporary feelings of loneliness among participants. To assess this, self-report measures of loneliness and other relevant state variables were collected to examine how isolation might affect different emotional states. Participants began the isolation sessions (iso-with-media and iso-total) by completing the same state variable measures that were also completed during the baseline session (loneliness, social activity craving, boredom, mood; T0). Participants completed these questions every hour during isolation (T1-T3; participants were reminded via an alarm) and immediately before completing the behavioural tasks (T4). At this time point, substance use and craving, and state anxiety (STAI-state) measures were completed. These data were included in exploratory analyses investigating whether changes in emotional states predicted susceptibility to peer influence or risk perception. Finally, during the iso-with-media session only, participants reported on their virtual social interactions during the session (estimated time spent engaging in virtual social interactions, which methods and platforms were used and with whom).

Following the questionnaires, participants carried out six experimental tasks (reported elsewhere; Tomova et al., 2025; Towner et al., 2024 and see pre-registration https://osf.io/kbgsv). The fifth task was a peer influence task, which is what we focus on here (see Fig. 1 for an overview of the experimental procedures).

2.3. *Peer influence task*

The peer influence task was adapted from a previous paradigm developed by our group (Knoll et al., 2015, 2017) and measured susceptibility to peer influence on risk perception by asking participants to rate the riskiness of different scenarios before and after seeing the purported rating of other young people. On each trial, participants were

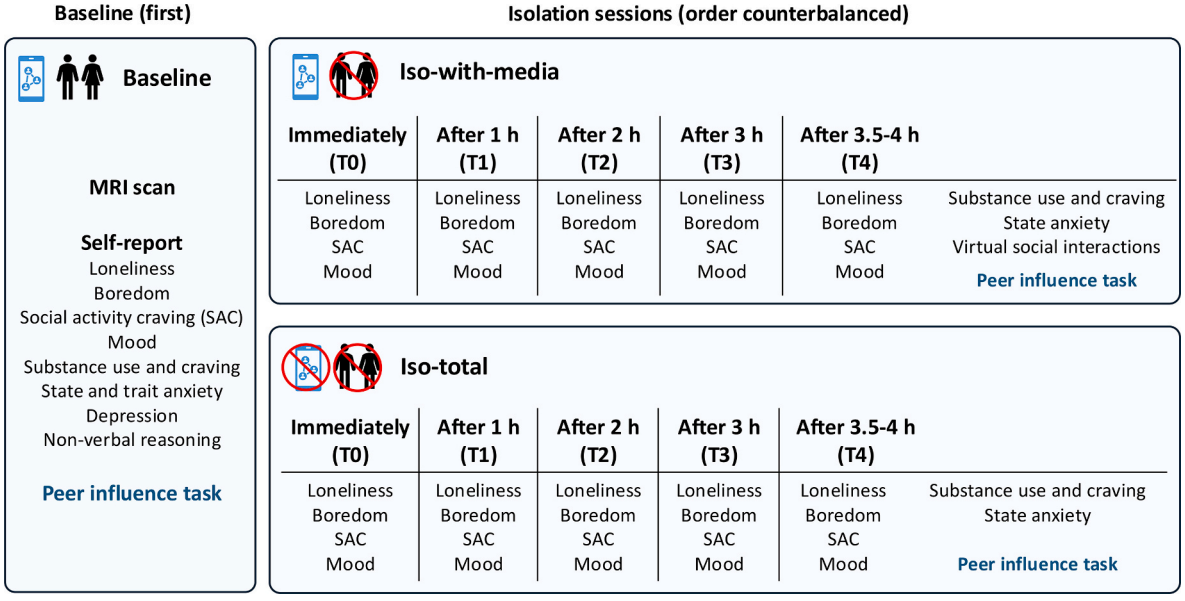

Fig. 1. Overview of experimental procedures.
Note. Participants began with a **baseline session** involving a structural and functional MRI scan, followed by all questionnaires and behavioural tasks. This included questions about momentary loneliness, boredom and social activity craving; substance use and craving (urge to drink alcohol or vape); mood (Positive and Negative Affect Scale [PANAS]); anxiety (State and Trait Anxiety Inventory [STAI-state and STAI-trait]); depression (Center for Epidemiological Studies Depression Scale) and a non-verbal reasoning task (Matrix Reasoning Item Bank [MaRs-IB]). Participants then completed behavioural tasks including the peer influence task. Participants returned on two separate occasions to complete the isolation sessions (iso-with-media, iso-total) with the order of isolation sessions counterbalanced across participants. The **iso-total** session involved complete isolation from social interactions, while the **iso-with-media** session allowed participants to engage in online virtual social interactions but restricted any in-person interaction. Participants completed the questions on momentary loneliness, boredom and social activity craving and mood at every hour during isolation (T0, T1, T2, T3) and a final time after 3.5–4 h of isolation (T4; exact duration of isolation randomised). At this point, participants additionally completed the substance use and craving questionnaire and STAI-state. In the iso-with-media session only, participants completed questions on their virtual social interactions during the session. Participants then completed the behavioural tasks before the session ended.

presented with a scenario and asked to indicate on a visual analogue scale how risky they thought this behaviour was (*rating 1*). The rating scale displayed the words "low risk" on the left and "high risk" on the right side. On each trial, the cursor was centred to the top middle position of the screen to avoid any anchoring bias. Following the participant's first rating, which was self-paced, the purported average risk rating from other young people for the same scenario was displayed for 2 s (*provided rating*). This provided rating was in fact positioned randomly along the scale bar, between the positions for 2 and 8 (see Fig. 2). This range was used instead of the full scale (1−10) to avoid extreme, implausible ratings. Participants were then asked to rate the same scenario again (*rating 2*) – this was self-paced. Though the primary aim was to understand how participants change their ratings after social information, risk perception ratings (rating 1) were also obtained. These data were included in an additional analysis to understand changes in risk perception across sessions, motivated by work demonstrating a link between social exclusion, a related concept to social isolation, and risky decision-making in humans (Mead et al., 2011; Meng, 2020; Peake et al., 2013; Twenge et al., 2002), and some research in animals linking social isolation with risk-taking (Mudra Rakshasa & Tong, 2020). The task was programmed in and run using PsychoPy (v2021.1.4; Peirce et al., 2019) and took approximately 10 mins.

2.3.1. Stimuli

Three sets of 30 risky scenarios (90 total) were counterbalanced across sessions for each participant, such that participants saw 30 new scenarios per session. The presentation of scenarios was randomised within each session. After submitting their first rating (rating 1), participants saw the purported average rating from other young people for that scenario and then rated the same scenario again (rating 2). Therefore, each participant made a total of 30 first ratings (rating 1) and 30 second ratings (rating 2) per session, reflecting 30 different risk scenarios. Each scenario described a situation with an element of potential health or safety risk, for example, "crossing the road without looking" or "eating raw meat" (adapted from Knoll et al., 2015, 2017; see Table 11 *Supplementary Materials* for full list). To ensure that the purported ratings of other young people (provided ratings) would be believable, each scenario was designed to reasonably elicit a range of perceived risk ratings. An image related to each scenario was added to make the task more engaging.

2.3.2. Measures

We recorded the position chosen by participants on the risk rating scale to six decimal places and rounded each trial to the nearest integer during pre-processing (1–10, low risk to high risk). This was to ensure that the trials in which participants changed their rating reflected true, purposeful change, rather than an artefact from the precision of the recorded ratings. The trial-level data, rather than participant averages, were included in the models to better capture variability and increase statistical power.

Susceptibility to peer influence was defined following Chierchia et al. (2020), using two dependent variables: influence probability and influence magnitude.

Influence probability refers to the probability of being socially influenced, that is, of participants changing their risk rating to conform to the rating of others. This measure was obtained by creating a binary trial-level variable, where 1 indicates conforming change (a change in rating in the direction of the provided rating) and 0 indicates no change in rating (rating 2 – rating 1 = 0) or anti-conforming change (a change in rating in the opposite direction of the provided rating). We also include a sensitivity model predicting influence probability from a dataset excluding anti-conforming trials (see *Supplementary Materials*).

Influence magnitude reflects the extent of change in risk rating and the direction, with positive values (>0) reflecting conforming change and negative values (<0) reflecting anti-conforming change. It is calculated by taking the change in ratings (rating 2 – rating 1) and transforming any conforming changes to positive (by taking the absolute value of change) and any anti-conforming changes to negative (by taking the absolute value of change and multiplying it by −1). We also ran a sensitivity model predicting influence magnitude from a dataset excluding anti-conforming trials (see *Supplementary Materials*).

We defined ***risk perception*** as the rating 1 responses from participants, as this represents their initial, subjective rating of perceived risk across a range of scenarios, before seeing any ratings from others.

2.4. Statistical analysis

Data were modelled using linear mixed effect models (*lme4* package, Version 1.1–36; Bates et al., 2015) using R Statistical Software (Version 4.4.2; R Core Team, 2024). All linear mixed models allowed intercept to vary by participant to account for the dependency in the data across repeated measures and maximal random slopes for the highest-order combination of within-participant variables in the first instance (Barr et al., 2013). Where models failed to converge, a process of reducing model complexity was conducted to obtain the most complex random effects structure that converged (final model syntax reported below).

Sum coding was used for the models. Main effects were inspected and the *emmeans* package in R (Version 1.10.2; Lenth, 2024) was used to conduct pairwise tests across estimated marginal means. Default methods for obtaining *p*-values using the *lmer* and *glmer* functions (*lme4*

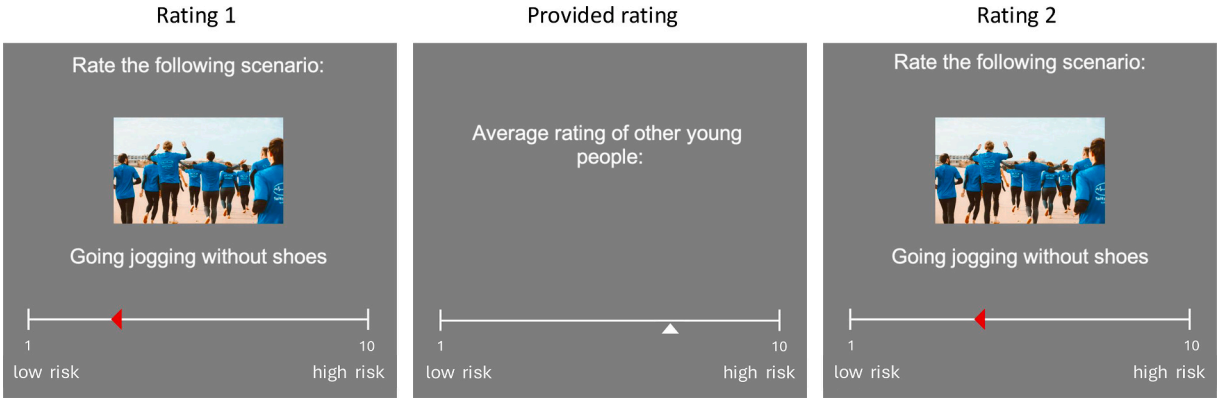

Fig. 2. Illustration of peer influence task.
Note. Participants were presented with a scenario and asked to imagine someone engaging in that activity (e.g., going jogging without shoes, standing under a tree during a thunderstorm, eating a raw egg). They were asked to rate how risky the activity was by marking their risk rating on a visual analogue scale between 1 "low risk" and 10 "high risk" (**rating 1**). Participants were then shown (2 s) the purported average rating of other young people related to that scenario (**provided rating**). This provided rating was in fact randomly generated between the positions for 2 and 8. Finally, participants were asked to rate the same scenario again (**rating 2**).

package; Bates et al., 2015) with the *lmerTest* package loaded (Version 3.1–3; Kuznetsova et al., 2013) were used (see *Supplementary Materials* for more information). We report unstandardised effect sizes throughout, except when specified. Any standardised effect sizes were calculated using the *effectsize* (Ben-Shachar et al., 2020), *sjPlot* (Version 2.8.16; Lüdecke, 2024) or *pwr* (Version 1.3–0; Champely, 2020) packages in R.

Potential careless or inattentive response patterns were investigated by examining response times, variance of responses and undertaking longstring analysis, which involved identifying the longest strings of identical responses for every participant in each session. This revealed that the longest string of identical responses was 5, which is considered acceptable across a total of 30 trials here. In addition, there were no participants for whom ≥80 % of their rating 1 responses were faster than 2 s, a cutoff score for survey response times suggested by Huang et al. (2012). Eight participants (20 %) responded faster than 2 s for the second rating (rating 2) in over 80 % of trials, however, this is considered acceptable due to the reduced time needed to read and process the risk scenario information for the second rating having just read this information in the first rating. Finally, there were no participants with a variance below 1 in either rating 1 or rating 2 in any session. Overall, these analyses indicated that participants were not inattentive or carelessly responding.

2.4.1. Social isolation on peer influence models

Our main independent variable of interest was ***session,*** which was included in the models as a 3-level predictor (baseline, iso-with-media, iso-total). A second 2-level predictor was the ***direction of influence***: since the provided ratings were randomly generated, this variable was created to identify whether the influence from others (provided rating) was in a more risk averse (higher risk) or more risk seeking (lower risk) direction compared to the participant's initial rating. As the magnitude of the difference between the provided rating and the participant's first rating was also random, we additionally included this as a third covariate in the models by creating a variable, ***delta***, which captured this magnitude. Delta is defined as the absolute value of the difference between the participant's first rating and the provided rating (|provided rating – rating 1|). Incorporating delta into the models accounts for the occurrence of a proportional relationship between the degree of social influence and how much participants changed their ratings (Chierchia et al., 2020; Foulkes et al., 2018; Knoll et al., 2015; Moutoussis et al., 2016). For analysis on peer influence, instances in which the provided rating matched the participant's first rating (i.e., delta = 0) were excluded (*n* trials = 450, 12.5 %; baseline = 122 trials, iso-with-media = 162 trials, iso-total = 166 trials), as these trials did not involve any social influence manipulation.

As influence probability followed a binomial distribution at the trial-level, all analyses with influence probability as the outcome variable used the binomial distribution with logit link function. Each of the two peer influence main models allowed for the 3-level interaction between the three predictors above (session, direction of influence, delta), as well as all lower-level 2-way interactions in the fixed effects.

Model formulae using R Statistical Software (Version 4.4.2; R Core Team, 2024).

Influence probability formula: Glmer(formula = influence probability ~ session * delta * direction of influence + (session + delta + direction of influence | participant), family = binomial(link = 'logit')).

Influence magnitude formula: Lmer(formula = influence magnitude ~ session * delta * direction of influence + (session | participant)).

2.4.2. Social isolation on risk perception model

We conducted analyses to understand the effect of isolation on ***risk perception.*** We defined risk perception as the rating 1 responses, as these represent a participant's subjective rating of risk across a range of scenarios, before any social influence has occurred. We investigated the effect of session (baseline, iso-with-media, iso-total) on risk perception (rating 1), allowing the intercepts to vary by participant as well as including session as a random slope.

Model formula using R Statistical Software (Version 4.4.2; R Core Team, 2024).

Risk perception formula: Lmer(formula = rating 1 ~ session + (session | participant)).

2.4.3. Exploratory analyses

We additionally conducted exploratory analyses to investigate the impact of each self-reported state variable (***loneliness***, ***boredom, social activity craving, positive mood, anxiety***) on susceptibility to peer influence (influence probability, influence magnitude) and on risk perception (rating 1). We modelled the association with each state variable and each outcome measure separately. In separate models, session was replaced by the state variable and all interactions were removed. The models initially included maximal random slopes for the highest-order combination of within-participant variables and allowed intercepts to vary by participant, however, due to convergence failures, the random effects structure for each model was simplified (see *Supplementary Materials*). We applied Bonferroni correction to our alpha significance level to account for the multiple comparisons (for interpreting peer influence models: $p < .005$ [0.05/10]; for risk perception models: $p < .01$ [0.05/5]).

In addition, we were interested in understanding the impact of inter-individual trait factors (***sex/gender, trait anxiety, depression, chronic loneliness***) on susceptibility to peer influence (influence probability, influence magnitude) and on risk perception (rating 1). In separate models, we added delta, direction of influence, as well as each trait variable and the interaction with session to separate models for each outcome measure, with intercepts varying by participant and maximal random slopes for the highest-order combination of within-participant variables for which the models would converge (see *Supplementary Materials*). In a separate model we added **age** as a predictor, with no interactions. We applied Bonferroni correction to our alpha significance level to account for the multiple comparisons (for interpreting peer influence models: $p < .005$ [0.05/10]; for risk perception models: $p < .01$ [0.05/5]).

3. Results

As described elsewhere (Tomova et al., 2025; Towner et al., 2024), participants in our sample reported average pre-existing levels of loneliness for their age group (University of California Los Angeles [UCLA] loneliness scale 0–80, $M = 35.6$, $SD = 6.2$, min-max = 25–48; Lasgaard, 2007; Russell, 1996) and high levels of social connectedness, including frequent social interactions (face-to-face/virtual interactions for a social purpose during the past month, $M = 36.0$, $SD = 32.2$, min-max = 10–150) and several close friends ($M = 7.6$, $SD = 4.2$, min-max = 2–20).

During the iso-with-media session, 35 out of 40 participants (88 %) reported engaging in virtual social interactions for more than 20 % of the session, and for 18 of these (45 %), this was greater than half the session (see Tomova et al., 2025 for further details). Due to limited statistical power to assess how differences in media usage impact peer influence or risk perception, no further analyses were conducted.

Detailed results regarding changes in self-reported state variables during isolation and across sessions are reported elsewhere (Tomova et al., 2025; Towner et al., 2024) and can be summarised as follows: participants showed increased state loneliness after 3 h of isolation compared with the start of the session, and this increase was higher in the iso-total session compared to iso-with-media. Similarly, positive mood decreased and boredom increased after 3 h of isolation, though neither differed across the two isolation sessions. There were no differences in state anxiety (T4) between all three sessions.

3.1. Peer influence effect

Before understanding the impact of isolation on susceptibility to peer influence, we sought to confirm whether social influence occurred. Participants changed their risk ratings in 42.73 % of trials (see Table 2 *Supplementary Materials*). Within these trials, conforming (78.9 %) and anti-conforming (21.1 %) changes did not occur with equal probability, as confirmed by an exact binomial test of the proportion of conforming change against 0.5 (frequency of conforming change = 0.79, Cohen's $h = 1.23$, 95 % *CI* [0.77, 0.81], $p < .001$).

We conducted *t*-tests to understand whether changes in risk ratings were significantly different from 0 and in which direction (positive = conforming, negative = anti-conforming). Indeed, averaged at the participant-level, there was a significant change in the ratings of participants from their first rating (before seeing provided rating) to their second rating (after seeing provided rating) in a conforming direction ($t = 0.34$, Cohen's $d = 1.27$, 95 % *CI* [0.25, 0.42], $p < .001$). This was true across all sessions (baseline, iso-with-media, iso-total) and directions of influence (lower risk, higher risk) (Bonferroni corrected alpha $p < .008$ [0.05/6]) (see Table 3 *Supplementary Materials*). These results indicate that participants were reliably influenced to conform to other young people's ratings. Further confirmation through the effect of delta is reported below.

3.2. Social isolation on peer influence

We defined two outcome measures to understand the impact of isolation on susceptibility to peer influence (influence probability and influence magnitude). For influence probability, we ran a GLMM investigating the fixed effects of *session* (baseline, iso-with-media, iso-total), *delta* (distance between participant's first rating and the provided rating) and *direction of influence* (lower risk, higher risk) on influence probability (likelihood of conforming change vs. anti-conforming change or no change). For the second outcome measure, we ran a linear mixed model predicting influence magnitude (magnitude of conforming [>0] or anti-conforming change [<0] or no change [0]), with the same fixed effects structure. There was no significant effect of session on susceptibility to peer influence in either model (influence probability [$\chi^2(2) = 3.33$, $p = .189$]; influence magnitude [$\chi^2(2) = 5.08$, $p = .079$]).

As expected on the basis of previous studies, there was an effect of delta in both models (Fig. 3). Delta significantly predicted influence probability ($B_{delta} = 0.12$, $SE = 0.04$, $p = .003$) (Bonferroni corrected alpha $p < .025$ [0.05/2]), suggesting that for every one-unit increase in delta, the odds of a participant showing conforming change increased by 12.5 %. In other words, the likelihood of conforming was higher when the degree of social influence exerted by peers (i.e., delta) was greater. For influence magnitude, the main effect of delta ($B_{delta} = 0.07$, $SE = 0.01$, $p < .001$) (Bonferroni corrected alpha $p < .025$ [0.05/2]) indicated that greater changes in ratings were observed when the degree of peer influence exerted was larger.

No other variables or interactions significantly predicted susceptibility to peer influence in either model (all *ps* > 0.074) (see *Supplementary Materials* for full results).

3.3. Effect of session on risk perception

We ran a linear mixed model investigating the fixed effect of *session* (baseline, iso-with-media, iso-total) on participants' first risk rating (rating 1; before seeing the provided rating). This first rating represents a measure of risk perception prior to any social influence.

This revealed that participants' first risk ratings differed across sessions, with pairwise comparisons (Bonferroni corrected alpha $p < .017$ [0.05/3]) showing that participants perceived scenarios as *less risky* after the iso-total session (estimated marginal mean = 5.07) compared to the iso-with-media session (estimated marginal mean = 5.40; $B_{iso\text{-}with\text{-}media\ -\ iso\text{-}total} = 0.33$, $SE = 0.13$, $p = .014$) (Fig. 4). There was no significant difference in risk perception between the baseline (estimated marginal mean = 5.33) and the iso-with-media session ($B_{baseline\ -\ iso\text{-}with\text{-}media} = -0.07$, $SE = 0.11$, $p = .525$) or the iso-total session ($B_{baseline\ -\ iso\text{-}total} = 0.258$, $SE = 0.14$, $p = .056$).

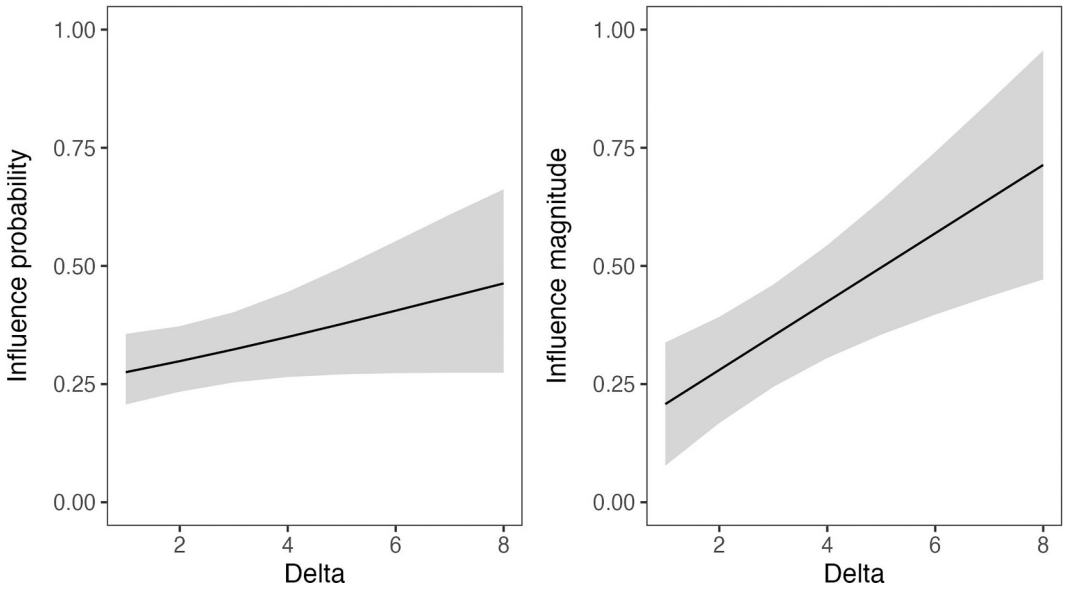

Fig. 3. Delta and susceptibility to peer influence.
Note. Relationship between susceptibility to peer influence and delta. The plotted line represents the means of the predicted values of influence probability (left panel) and influence magnitude (right panel) at each level of delta (1–8). The means of the predicted values are derived from the model across each level of session (baseline, iso-with-media, iso-total) and direction of influence (lower risk, higher risk). Shaded areas represent the corresponding 95 % confidence intervals. **Influence probability** = likelihood of demonstrating conforming change compared to no change or anti-conforming change. **Influence magnitude** = magnitude of conforming change (>0) or anti-conforming change (<0) or no change (0). **Delta** = the distance between a participant's first rating and the provided rating.

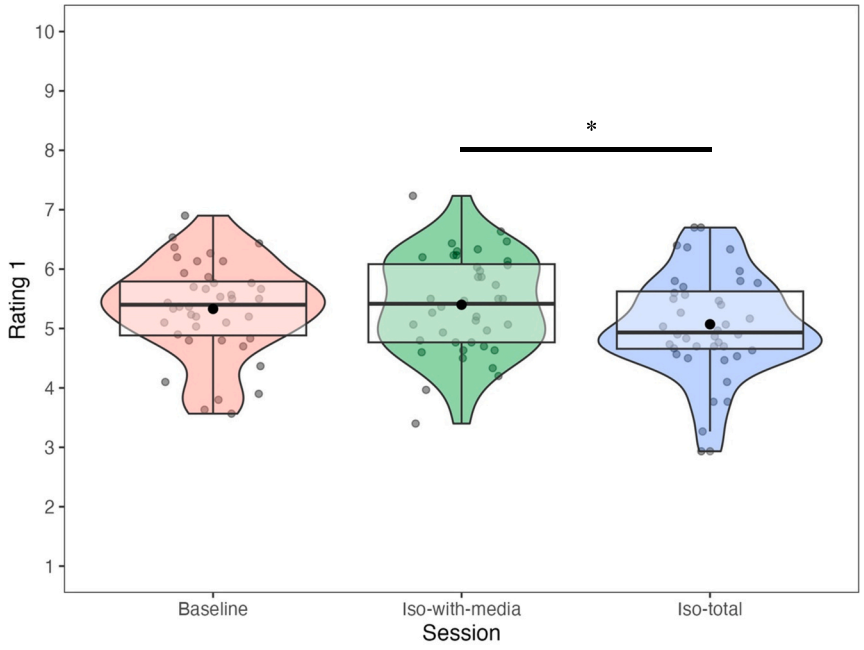

Fig. 4. Perceived risk by session.
Note. Session plotted against first risk ratings (a measure of risk perception). Grey dots represent average rating 1 (1–10) across trials (randomly jittered across the x-axis) for each participant, in each session (baseline, iso-with-media, iso-total). Black dots represent the mean rating 1 across participants in each session. The violin plots represent the kernel density of rating 1. Boxplots represent the interquartile range and the centre line is the median.
* indicates significance at a Bonferroni alpha level correction $p < .017$.

3.4. Effects of state and trait variables on peer influence and risk perception

None of the state or trait variables predicted influence probability (all *ps* $>$ 0.018) and only loneliness predicted influence magnitude, however, this effect was very small (std. $\beta = 0.07$, $p < .001$) (all other *ps* $>$ 0.022) (see *Supplementary Materials*). None of the state or trait variables predicted risk perception (all *ps* $>$ 0.053) (see *Supplementary Materials*).

To summarise, the results demonstrate that there was a significant peer influence effect across all three sessions, with participants showing changes in their risk ratings after viewing the ratings of other young people. However, there was no evidence of an effect of social isolation on this susceptibility to peer influence. Finally, risk perception was lowered after the iso-total session compared to the iso-with-media session.

4. Discussion

The current study investigated the effect of acute social isolation on susceptibility to peer influence and risk perception in adolescents aged 16–19 years. The results replicate previous evidence indicating that adolescents are likely to conform to peer opinions on risk perception; simply being aware of the social group's evaluation is associated with changes in one's own response in mid-adolescence. Although adolescents were susceptible to influence from other young people, we found no significant effect of short-term isolation on this peer influence susceptibility. Thus, our pre-registered hypotheses were not supported. This suggests that peer influence may be unaffected by short periods of being alone. This does not align with previous literature examining the effects of social *exclusion,* a more active rejection or ostracism from the social group, on social influence, suggesting that not all forms of social disconnection produce the same sociocognitive consequences. However, total isolation was associated with a decrease in risk perception, with participants rating situations as less risky following a 3.5–4-h period of total isolation compared to isolation with access to virtual social interactions. This indicates that, even after a brief period of isolation from in-person and virtual social interactions, adolescents might judge potentially unsafe or uncertain situations as less risky. These findings suggest that social disconnection may alter adolescents' ability to perceive risk, which could have implications for how they behave in real-world situations, as discussed below.

4.1. Peer influence effect

In line with previous research, we found a significant peer influence effect in participants aged 16–19 years. After viewing the average risk rating of other young people, participants were more likely to change their own rating in line with their peers, and to change it to a greater extent. Previous literature has demonstrated that individuals often conform to the views of others and that this tendency is highest in childhood and gradually decreases in adolescence and emerging adulthood (Chierchia et al., 2020; Cialdini & Goldstein, 2004; Foulkes et al., 2018; Gardner & Steinberg, 2005; Knoll et al., 2015, 2017).

We found that the larger the difference between the participant's first rating and the provided rating, the *more likely* participants were to conform to this influence and the *greater the magnitude* of their conformity. The results indicate that the peer influence effect was stronger when the rating of other young people was further from participants' own first rating. This is in line with previous research demonstrating a proportional relationship between social influence and the distance between one's own initial behaviour and the observed behaviour of others (Foulkes et al., 2018; Knoll et al., 2015, 2017; Moutoussis et al., 2016).

It has been proposed that adolescents are susceptible to peer influence due to the avoidance of social risk, which refers to the risk of being excluded or rejected by one's social group (Blakemore, 2018; Blakemore & Mills, 2014). Participants may have changed their ratings to be more similar to those of their peers in order to avoid social risk (Blakemore, 2018). Alternatively, participants might have changed their ratings due to uncertainty in their own opinions, believing the risk ratings of others to be more accurate (Deutsch & Gerard, 1955; Moutoussis et al., 2016;

Reiter et al., 2021; Toelch & Dolan, 2015). Understanding the motivations underlying peer influence has implications for promoting positive decision-making during adolescence.

4.2. Social isolation on peer influence

We did not find evidence for our hypothesis that susceptibility to peer influence would increase following a period of brief isolation. There was no significant difference between peer influence effects in the isolation and no isolation sessions, which could have been due to insufficient power. Due to a lack of existing experimental work investigating the effect of social isolation on peer influence, there were no evidence-based effect sizes to use in a power analysis and while there was sufficient power to detect medium size effects of isolation on loneliness, the relatively small sample size may have been underpowered to detect small effects of isolation or loneliness on susceptibility to peer influence. It is also possible that the task itself remediated any effects of social isolation on peer influence, as it may have invoked thoughts about other people, which could have served as a reminder of social connection and relationships, reducing the salience of isolation.

An alternative explanation is that there is in fact no effect of a brief period of being alone, with or without access to virtual social interactions, on susceptibility to peer influence. Previous work has demonstrated a link between peer influence susceptibility and social *exclusion* (Falk et al., 2014; Wasylyshyn et al., 2018; Williams et al., 2000), and a similar effect of social isolation might have been expected in our study. This discrepancy might be because the social disconnection experienced during isolation does not elicit the same motivational or emotional responses as active social exclusion. Social exclusion can be perceived as a direct threat to social belonging (DeWall & Richman, 2011; Williams et al., 2000) which in turn might motivate social conformity in order to regain acceptance and connection. This contrasts to the more passive state of simply being alone.

This distinction has theoretical implications as it suggests that the underlying reason for the absence of social connection has consequences for social conformity. Practically, this implies that not all socially disconnected adolescents are equally vulnerable to social influence. For instance, adolescents who are temporarily alone, whether through choice or practicality, may not experience increased susceptibility to peer influence, compared to adolescents who are deliberately excluded due to bullying or ostracism. Future work directly comparing the effect of social isolation, as manipulated here, and social exclusion, for instance, using the Cyberball task, on susceptibility to peer influence would provide insights into the distinct psychological consequences that different forms of social disconnection might have.

4.3. Social isolation on risk perception

We found a reduction in *risk perception* following isolation, such that participants rated scenarios as less risky after being completely socially isolated when compared to isolation with access to virtual social interactions. The two isolation sessions were fully counterbalanced and thus it is unlikely that order effects could explain this difference. These findings suggest that deprivation of virtual social interactions may uniquely impact adolescents' risk perception, leading them to view everyday situations as less risky, while having access to virtual social interactions may mitigate this effect. This has theoretical implications for understanding the role of the digital and virtual world on adolescent cognition and decision-making in the context of risk-taking.

It is important to note that during the isolation session with access to virtual social interactions, participants were not instructed to engage in any specific activities and could therefore choose whether or not to partake in virtual interactions. While 35 out of 40 participants reported engaging in virtual social interactions for more than 20 % of the session (see Tomova et al., 2025 for more detail), we were not able to assess how differences in digital media usage impacted our results due to limited statistical power. As such, it remains unclear whether the potential remediating effects of this session were due to participants' engagement in virtual social interactions or simply by the availability of digital media more broadly, such as watching TV, listening to music or passively browsing. Future work should manipulate the type of digital media available during isolation (e.g., social vs. non-social) to disentangle the mechanisms through which isolation might influence risk perception.

While little research has directly examined the link between social isolation (or loneliness) and risk-taking, work on social exclusion has shown mixed effects on risky decision-making. Peer rejection has been linked to increased risk-taking in the form of aggression, substance use and sexual risk behaviours in adolescent populations (Newcomb et al., 1993; Prinstein & La Greca, 2004). Experimental studies have also shown an increase in risky decision-making following social exclusion (Meng, 2020; Peake et al., 2013; Twenge et al., 2002). In contrast, one study demonstrated an increase in risky decisions following social *inclusion*, rather than exclusion (Lorenz & Ferdinand, 2024). However, the effects of social exclusion depended on whether this was tied to social rank and whether performance was disclosed. Similarly, other work has demonstrated effects on risky decision-making, but only when accompanied by an opportunity to reaffiliate with the group using this behaviour (Mead et al., 2011). This indicates the complexity of the relationship between risk-taking and social exclusion, with several contextual factors playing a role, such as social learning and peer presence.

An alternative explanation for lowered risk ratings after total isolation could relate to the experience of boredom during isolation. State boredom has been associated with increased risk-taking (Kılıç et al., 2020; Miao et al., 2020), with the suggestion that boredom serves as a signal that current goals are unfulfilling, thereby motivating individuals to seek novel or stimulating experiences, sometimes through riskier choices (Bench et al., 2021; Bench & Lench, 2013). In one study, state boredom resulted in more optimistic perception of risk (Bench et al., 2021). As well as reduced risk perception, perhaps unsurprisingly, we found that self-reported boredom increased to a greater extent in the total isolation session compared to isolation with access to virtual social interactions (see Tomova et al., 2025; Towner et al., 2024 for full results). However, exploratory analyses revealed that boredom was not significantly associated with risk perception in our sample, suggesting that boredom may not have been the direct driver behind the change in risk perception (see *Supplementary Materials*).

It is important to note that the current study measured risk perception and there were no measures of actual risk-taking behaviour. Although risk perception has been linked to risky decision-making (Grevenstein et al., 2015; Sheeran et al., 2014; Sitkin & Weingart, 1995; Weber et al., 2002), this relationship is not always straight forward. For example, risk perception alone is not enough to drive risky behaviour; emotional and motivational processes related to reward and threat also play a role (Baker & Galván, 2020). Therefore, while our findings provide insight into how acute social isolation might affect risk perception, future research is needed to determine whether, and under what conditions, this translates to risk-taking behaviour, for instance, by further exploring the reward and threat aspects of risky decision-making.

4.4. Strengths and limitations

A key strength of the current study is the experimental design allowing for the direct comparison of susceptibility to peer influence and risk perception across different isolation conditions. This allows for stronger causal conclusions compared to observational studies. The design also benefitted from a within-participant approach, which reduces variability from individual characteristics and thus allowed for a better understanding of the effect of isolation on adolescent social behaviour and cognition.

However, several limitations must be acknowledged. The small sample size may not have been sufficient to detect small effects on peer influence. In addition, while the experimental aspect of the design was a key benefit, the non-ecological nature of the isolation experience, which is unlike typical periods of being alone during daily life, may limit the generalisability of the findings. As such, responses to isolation in real-life may differ compared to the controlled experimental conditions here. The isolation period was also relatively brief (3.5–4 h) and its effects might differ from the effects of more prolonged or chronic loneliness. Our sample had relatively low levels of chronic loneliness as this was an inclusion criterion, which limits the generalisability of the findings to the broader adolescent population.

Although analytical checks into careless or inattentive responding did not reveal any evidence of this, we cannot be certain that participants were answering with full attention, particularly after a potentially intense isolation period. Similarly, due to the demanding protocol, we decided to measure both risk perception and peer influence within one task, meaning we did not obtain any measures related to other aspects of risky decision-making, such as benefit perception or risk engagement. As part of the larger study, the effect of isolation on reward processing was examined in a separate paper focusing entirely on those areas (Tomova et al., 2025).

While the narrow age range of our adolescent sample (16–19 years) reduced variation due to age-related differences, it limits our ability to examine any developmental differences. Future studies should investigate age comparisons to explore potential age-related or developmental variation in how social disconnection influences susceptibility to peer influence or risk perception.

5. Conclusion

The present study replicated previous studies showing significant susceptibility to peer influence, with adolescents aged 16–19 years shifting their risk perception judgements towards that of their peers. This peer influence effect was not significantly altered by an acute period of social isolation. However, the results showed that total social isolation (from both in-person and virtual social interaction) led to a decrease in risk perception, compared to social isolation with virtual social interactions. This finding suggests that judgements about the riskiness of different situations could be altered even after short periods with an absence of both in-person and virtual social connection. It is unclear whether a deprivation of virtual social interactions, or digital media generally, is driving the decrease in risk perception after total isolation, and future research examining which social contexts produce greater change in risky decision-making would provide valuable insight. This study provides preliminary insight into the effect of social isolation on risk perception in adolescents and has implications for understanding the social environment in relation to decision-making.

CRediT authorship contribution statement

Kirsten Thomas: Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Emily Towner:** Writing – review & editing, Project administration, Methodology, Investigation, Conceptualization. **Livia Tomova:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **Gabriele Chierchia:** Writing – review & editing, Resources, Formal analysis. **Sarah-Jayne Blakemore:** Writing – review & editing, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

Funding sources

K.T. is funded by the UKRI Economic and Social Research Council and the Gonville Research Studentship. E.T. was funded by a Gates Cambridge Scholarship and St John's College Benefactors' Scholarship. L.T. was funded by Henslow Research Fellowship from the Cambridge Philosophical Society. L.T. is funded by the Wellcome Trust (grant no. 321242/Z/24/Z). S-J.B. is funded by the Wellcome Trust (grant no. WT107496/Z/15/Z; WT227882/Z/23/Z), the Jacobs Foundation and the University of Cambridge. The funding sources were not involved in the design of this study, nor the collection, management, analysis and interpretation of data nor the decision to submit for publication.

Open practices

Pre-registration: https://osf.io/kbgsv

Declaration of competing interest

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2025.105886.

Data availability

Data and materials associated with this research have been deposited in the Open Science Framework (OSF) and are publicly available at https://osf.io/mdrey.

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