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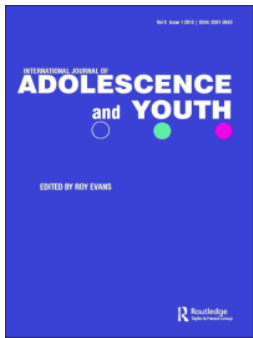
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Is adolescence believed to be a period of greater risk taking than adulthood?

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ABSTRACT

Little is known about adolescents' own beliefs regarding their level of risk taking or regarding peer influence on the latter. This is an important matter given that beliefs influence judgements and decisions. With the present study, we aimed to study adolescents' and adults' beliefs about adolescents' risk taking compared to adults' risk taking, and beliefs about peer influence on risk taking. To this end, an experimental design was used. A cross-sectional study included 56 adolescents and 43 adults, who completed a questionnaire asking about adolescents' and adults' risk-taking propensity and a syllogistic reasoning task designed to indirectly study these beliefs. Both direct and indirect measures indicated that adolescents perceived adolescence as a period of higher risk taking compared to adulthood, and believed peer presence to promote this effect. Adults perceived this detrimental effect of peers to be present irrespective of age. We discuss the implications of these results in terms of social representation.

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Introduction

Adolescence, which is a transition phase from childhood to adulthood, is often described as a period of greater risk taking (compared to both childhood and adulthood, Casey et al., 2008). Given the potentially serious consequences of higher risk taking for well-being and health, it is important to understand its underpinnings. Although several studies have already identified important factors leading to greater risk taking, such as peer presence (Crone & Dahl, 2012; Galvan, 2010; Shulman, Harden, et al., 2016; Somerville et al., 2010), little is known about adolescents' own beliefs and knowledge regarding their level of risk taking or regarding the influence of their peers on the latter. This is an important matter given that beliefs influence judgements and decisions (Ferguson & Bargh, 2004). With the present study, we aimed to answer the following questions: (1) Do adolescents and adults perceive adolescence as a period of higher risk-taking, compared to adulthood? (2) Do adolescents and adults perceive the role of peer presence on this effect? We aimed to answer these questions using direct (i.e. explicit) and indirect (i.e. implicit) measures of beliefs.

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Adolescence: a period of heightened risk taking?

A number of studies indicate that adolescence is a period of heightened risk taking, including higher levels of substance abuse, unprotected sex, and risky automobile driving (e.g. Casey et al., 2008, 2011; Dahl, 2004), with many risk-taking behaviours emerging or peaking in adolescence (Boyer, 2006; Crone & Dahl, 2012; Galvan, 2010). Among risk-taking behaviours, maladaptive behaviour (e.g. self-harm) usually begins around 12–13 years of age (Stänicke et al., 2018). Greater risk taking can be defined as a higher propensity to engage in potentially harmful behaviours, which leads to an increase in morbidity and mortality rates during adolescence (Blakemore, 2018; Crone & Dahl, 2012). Adolescent risk-taking may result from independence-seeking behaviours designed to increase success upon separation from the protection of the family (Casey et al., 2008; Stänicke et al., 2018), and to learn the consequences of alternative and unusual choices (Do et al., 2020). Stänicke et al. (2018) argue that risk behaviours may be the consequence of a difficulty in expressing their experiences with other and in regulating difficult feelings (e.g. expressing anger or frustration to their peers may conflict with their need of peer acceptance).

Systematic research does not always support the prevailing stereotype of adolescence as a period of irrational and potential harmful risk-taking behaviours (Blakemore, 2018; Defoe et al., 2019; Steinberg, 2007; Telzer et al., 2022); maladaptive risk taking may characterize only a subset of adolescents (Romer et al., 2017). In laboratory settings, some studies have even reported no increase in risk taking (e.g. Van Leijenhorst et al., 2008) or risk perception (Knoll et al., 2015) in adolescents compared to adults. When it comes to using information about probabilities and rewards, or perceiving the risks associated with a given situation, adolescents sometimes exhibit performance that is similar to that of adults (Osmont et al., 2017; Romer et al., 2017; Steinberg, 2007). Adolescents can even exhibit lower levels of risk taking than young adults, for instance with risk-taking behaviours (e.g. marijuana consumption and binge drinking) peaking in the mid-twenties rather than in adolescence (Romer et al., 2017; Steinberg et al., 2018; Tomova & Pessoa, 2018).

The influence of social contexts on risk-taking behaviour

To understand adolescent risk taking, it is critical to consider the social context and, more specifically, the influence of peers (e.g. Defoe et al., 2019; Shulman, Smith, et al., 2016). When adolescents are in the presence of peers (fictive or real), in both competitive and non-competitive settings, they are prone to demonstrate more reckless driving behaviour (Chein et al., 2011), to prefer immediate rewards over delayed rewards (O'Brien et al., 2011; Weigard et al., 2014), to conform to their peers' perceptions of the riskiness of everyday situations (Knoll et al., 2015), or to express less regret after their decision (Habib et al., 2015). The presence of peers affects daily risk-taking behaviours, such as alcohol abuse or cannabis use (Teunissen et al., 2012, 2014; Tucker et al., 2014).

Neurodevelopmental models postulate that an imbalance between two brain systems may explain the heightened levels of risky behaviours in adolescence compared to childhood and adulthood (Galvan, 2010; Steinberg, 2008). On the one hand, the relative maturity of the emotional system during adolescence results in greater sensation seeking and reward seeking and, consequently, in increased risk taking (Galvan, 2010; Steinberg et al., 2018). On the other hand, the cognitive control system, which is still immature, fails to regulate these emotional processes (Steinberg et al., 2018). This is particularly true in situations that are susceptible to generating strong emotions, such as social contexts, which conducts the emotional system to respond more strongly to cues signalling the potential rewards of risky behaviour, and consequently lead to heightened levels of risk taking (Casey et al., 2008; Chein et al., 2011; Shulman, Harden, et al., 2016).

Alternatively, some recent studies have highlighted the importance of risk exposure and social norms to better apprehend adolescents' risk taking (e.g. Defoe et al., 2019; Romer et al., 2017). Defoe et al. (2019) argue that adolescence-related heightened levels of risk taking, compared to childhood,

would reflect a greater number of risk opportunities, qualified as *risk exposure*. Given that adolescents spend more time with their peers and are more often unsupervised by adults than children, they find themselves in more risk-prone situations and are more likely to be influenced by others. Thus, peer influence can be described as creating *social risk exposure*, where adolescents are affiliated with risk taking through their peers. However, peer influence is not always negative, and peer effects on risk taking may also be positive, as a function of expectations regarding the appropriate behaviours promoted by their peers (Fryt et al., 2021; Osmont et al., 2021; Tomova & Pessoa, 2018), which has been qualified as ‘peer norms’ (Tomova et al., 2021). Social influence (such as social compliance or conformity) is not specific to adolescence and can also be observed in adulthood (Cialdini & Goldstein, 2004). However, unlike adolescence, adulthood is not commonly perceived as a period of heightened risk taking, and adults’ risk perception and risk-taking behaviours seem to be less susceptible to peer influence (Chein et al., 2011; Knoll et al., 2015).

Perceptions about adolescents’ risk-taking and the influence of social context on behaviours

Several studies indicate that adults from various countries endorse adolescent stereotypes of rebelliousness, moodiness and impulsivity (Chan et al., 2012; Gross & Hardin, 2007; Hines & Paulson, 2006; Telzer et al., 2022; Trzesniewski & Donnellan, 2014). Such negative characteristics refer to negative stereotypes of adolescence that are perpetuated by media representations (Telzer et al., 2022). However, few studies have focused specifically on risk taking, and on adolescents’ own beliefs about their risk-taking proneness during adolescence. This blind spot is a matter of concern given that beliefs are powerful drivers of judgements and behaviours (Telzer et al., 2022). Specifically, when individuals categorize themselves as belonging to a given social group, stereotypical information about that group is automatically activated (Ferguson & Bargh, 2004). Stereotype activation (Kunda & Spencer, 2003) can then have a significant impact on the ways individuals make sense of their environment and on their own behaviours (Cunningham & Macrae, 2007; Dijksterhuis & Bargh, 2001; Tomova et al., 2021; Wheeler & Petty, 2001). Adolescents are also sensitive to perceived social norms, which can influence their behaviour: the perception that peers frequently engage in a particular behaviour is an important determinant for the engagement in this particular behaviour (Ciranka & Bos, 2021; Fryt et al., 2021). Negative stereotypes of adolescence have been related to increased activation of the prefrontal cortex during cognitive control, and to increased risk taking (Qu et al., 2018). On the contrary, a counter-stereotyping intervention led to better performance on academic tasks and higher academic engagement (Qu et al., 2020). Consequently, the perception that adolescents – as a social group – are more prone to risk taking may reinforce their levels of risk-taking behaviour.

Evaluating beliefs using an indirect measure

If beliefs can be measured by using direct measures, such as questionnaires (e.g. Chan et al., 2012; Gross & Hardin, 2007), reasoning tasks can also be useful tools to identify intuitive beliefs (De Neys & Van Gelder, 2009). Specifically, when perceptions and beliefs influence the ability to reason logically, they lead to a well-known reasoning bias called the belief-bias effect (De Neys & Van Gelder, 2009; Eliades et al., 2012; Evans, 2003). This effect can be defined as a logical error that some people make when they rely on their personal intuitive beliefs rather than on logical principles in solving reasoning problems. This bias can be detected through the use of syllogisms, which are composed of two premises and a conclusion, such as the following:

Premise 1 “Things with an engine need fuel,

Premise 2 Convertible sports cars need fuel,

Conclusion Therefore, convertible sport cars have an engine.”

Table 1. Examples of the syllogisms displayed to the participants in the present study according to their structure (no conflict and conflict) for each type of content (control, adolescent-related and adult-related content) translated in English.

	Structure	Control content	Adolescent-related content	Adult-related content
NO-CONFLICT	Valid High-believable	Ravens are birds, Birds have wings that allow them to fly, Thus, ravens have wings that allow them to fly.	Adolescents smoke pot when they go out, When they go out adolescents are in groups, Thus, adolescents smoke pot when they are in groups.	Adults smoke pot when they go out, When they go out adults are in groups, Thus, adults smoke pot when they are in groups.
	Invalid Low-believable	Big cars need fuel, Airplanes carrying passengers need fuel, Thus, airplanes carrying passengers are big cars.	Friendly people are friends, Adolescents skip class when there are no friendly people, Thus, adolescents skip class when there are no friends.	Friendly people are friends, Adults skip class when there are no friendly people, Thus, adults skip class when there are no friends.
CONFLICT	Valid Low-believable	Swallows are birds that fly, Birds that fly have bright multicolored feathers, Thus, swallows have bright multicolored feathers.	Adolescents smoke pot when they go out, When they go out adolescents are alone, Thus, adolescents smoke pot when they are alone.	Adults smoke pot when they go out, When they go out adults are alone, Thus, adults smoke pot when they are alone.
	Invalid High-believable	Things with an engine need fuel, Convertible sports cars need fuel, Thus, convertible sports cars have engines.	Friends are nice people, Adolescents skip class with nice people, Thus, adolescents skip class with their friends.	Friends are nice people, Adults skip class with nice people, Thus, adults skip class with their friends.

Participants are asked to determine whether the conclusion of a syllogism follows logically from two premises. In conflict (incongruent) syllogisms, a conclusion can be logically invalid but believable (such as in the example above, where it is believable that convertible sport cars have an engine, but the conclusion does not logically follow from the two premises); or logically valid but unbelievable (such as in the following example: 'All mammals can walk, whales are mammals, therefore, whales can walk'). In no-conflict (congruent) syllogisms, the conclusion is either logically valid and believable, or logically invalid and unbelievable (see [Table 1](#) for examples of no-conflict syllogisms).

Most people are tempted to endorse a believable conclusion even if it does not follow logically from the given premises and to reject an unbelievable conclusion that follows logically from the given premises. The belief-bias effect thus translates into a decrease in correct responses for conflict syllogisms compared to no-conflict syllogisms (i.e. syllogisms for which logic and belief lead to the same response). This paradigm has been previously used to evaluate personal beliefs indirectly without asking participants to explicitly explain their beliefs (Vroling & de Jong, 2009), and could constitute an adequate tool to evaluate beliefs about peer influence on adolescents' and adults' risk taking.

The current research

Our general aim was to study beliefs about adolescents' risk taking. Our first goal was to contrast adolescents' and adults' beliefs about risk taking in adolescence compared to risk taking in adulthood. Beliefs were also compared to the ways in which participants evaluated themselves to assess consistency between personal beliefs and reported behaviours. Increased risk taking during adolescence may be (at least partly) explained by the fact that adolescents are aware of a social norm that defines adolescence as a time of increased risk taking. If this is true, then adolescents and adults should associate adolescence more strongly with risk taking and impulsivity than with cautiousness

and reason, and this should less be the case for adulthood (Gross & Hardin, 2007; Hines & Paulson, 2006). We expect to observe a perception of higher risk taking in adolescence, compared to adulthood, in both age groups. If this belief is an exaggeration of adolescence-related stereotypes (Chan et al., 2012), then adolescents should evaluate themselves as taking fewer risks than the adolescent population in general, conducting adolescents to a higher perception of risk taking in adolescence compared to oneself.

Our second goal was to determine whether adolescents' and adults' beliefs about adolescents' risk-taking were related to peer presence. We hypothesized that adolescents and adults would be aware of the influence of peers. This would drive both age groups to be more prone to endorse statements in agreement with the belief that adolescents take more risks when they are with their peers, compared to statements about risk taking in the absence of peers.

Third, we aimed to control for biases related to the usage of direct (explicit) measures of beliefs by using an indirect measure. To do so, we employed the well-known belief-bias effect (De Neys & Van Gelder, 2009; Eliades et al., 2012; Evans, 2003), namely, syllogisms for which the conclusions were either in accordance or discordance with the belief that adolescents take more risks when in the presence of their peers than in the absence of peers. Previous studies have used this paradigm to evaluate personal beliefs indirectly without asking participants to explicitly explain their beliefs, thus avoiding possible response biases such as social desirability (Vroling & de Jong, 2009, 2010). As is the case for the explicit measure, we hypothesized that the expectations about adolescents' risk taking in the presence of peers would bias participants' responses. Consequently, if adolescents and adults believe that adolescents take more risks in the presence of their peers, they would provide more incorrect responses to conflict syllogisms than to no-conflict syllogisms, thus demonstrating a belief-bias effect for adolescent-related syllogisms. We expect the belief-bias effect to be stronger for adolescent-related syllogisms than for adult-related syllogisms.

In summary, we compared late adolescents' (16 to 18 years of age) to adults' (30 to 60 years of age) beliefs about risk taking in adolescence or adulthood, in the presence or absence of peers, using both direct (explicit) and indirect (implicit) measures of beliefs.

Method

Participants

One hundred and ten French-speaking individuals from two age groups participated in this study: 60 adolescents recruited in two Parisian secondary schools (42 females, age range = 16.0 to 18.8 years, $M = 17.2$ years, $SD = 0.8$) and 50 adults were recruited via social networks and through word of mouth (39 females, age range = 30.0 to 60.8 years, $M = 44.2$ years, $SD = 8.9$). Among the adult participants, 35 (70%) had children ($M = 2.61$ children, $SD = .98$) and, among them, 26 (52%) were parents of adolescents or adults. The gender distribution did not differ significantly across age groups, $\chi^2(1, N = 175) = .133, p = .72$. Sample size was determined pre hoc by running a priori power analysis using G*Power 3.1.9.2 (Faul et al., 2009 – Dusseldorf, Germany), showing that a minimum of 74 participants would be needed to detect a small effect size of 0.20 (according to Cohen's effect size conventions) on the three (Target: adolescence vs. adulthood vs. oneself) x two (Age Group: adolescents vs. adults) interaction with a power ($1 - \beta$) set at .80 and α set at .05.

The distribution of adults' socio-professional categories across our sample is reported in the supplementary material. Ethnicity data were not collected as such collection is discouraged by the French data protection regulation (RGPD) and by the National Commission of Informatics and Liberty (CNIL). Given that we were interested in beliefs about risk-taking during adolescence, we focused on 16-to-18-year-old adolescents given that they tend to encounter more risk-taking opportunities than younger adolescents (Defoe et al., 2019).

Participants who failed to provide a correct answer on more than one verification item in the questionnaire (out of 3) were excluded (the verification item read: 'this is a verification item, check

X on this question', where X was a value randomly selected between 1 and 10). In addition, questionnaire and syllogism data were not analysed if the participant did not complete the task. The final sample consisted of 54 adolescents and 40 adults for the questionnaire, and 47 adolescents and 41 adults for the syllogisms.

All participants were tested in accordance with international norms governing the use of human research participants. The research was pre-approved by the data protection officer of the institution and by the ethical board of the institution (The Reference to indicate is "CE-P8-2021-10"). All of the participants provided informed consent and adolescents provided parental written consent in accordance with the Declaration of Helsinki.

Materials and procedure

The study was computerized and lasted approximately 40 minutes. Adolescents completed the tasks at their school, in small groups composed of approximately 10 individuals. They did not have the possibility to collaborate. Adults completed the tasks online. Participants first provided their demographic information (age, gender, and native language). The study was then divided into two parts: a questionnaire and a syllogistic task. The ordering of the presentation of the two parts was counterbalanced across participants. Each item (of both the questionnaires and the syllogistic task) remained on screen until a response was given, and participants could not change their answer after validating it.

Questionnaires

The questionnaire, which consisted of 93 items, was composed of a risk-taking scale, a risk perception scale and statements relating to risk-taking behaviours in the absence or presence of peers, described below.

16-item risk-taking scale

The participants rated how frequently they had engaged in 16 daily-life risky behaviours (adapted from Lejuez et al., 2003; Telzer et al., 2015; e.g. "Being drunk", "Using cannabis/marijuana") over the past six months using a 10-point Likert scale (1 = 'never', 10 = 'very often'; see the supplementary material for a complete list of the statements).

15-item risk perception scale

The participants rated the level to which each of 15 adjectives applied to adolescence, to adulthood, and to themselves on a 10-point Likert scale (from 1 = 'not at all' to 10 = 'very much'; adapted from Gross & Hardin, 2007). Among the adjectives, five were distractors unrelated to our experimental aims (i.e. generous, lazy, greedy, funny, and sporty), and ten were test adjectives related to our experimental aims, of which five were related to risk taking and impulsivity (i.e. reckless, impulsive, risk taker, spontaneous, and thoughtless), and five were related to cautiousness and reason (i.e. cautious, thoughtful, measured, serious and reasonable). The order of presentation of the adjectives was pseudo-randomized and the sections (adolescence vs. adulthood vs. themselves) were counter-balanced across participants.

Statements relating to risk-taking behaviours in the absence or presence of peers

The participants evaluated the degree to which they agreed with 16 statements: eight statements related to adolescents' and adults' risk-taking behaviours in the presence of peers (e.g. 'Teenagers smoke pot when they are in groups' or 'Adults engage in challenges when they are with friends,') and eight statements related to risk-taking behaviours in the absence of peers (e.g. 'Teenagers smoke pot when they are alone' or 'Adults engage in challenges without their friends') measured on a 10-point Likert scale (1 = 'not at all' to 10 = 'very much'; see the supplementary material for a complete list of the statements). The statements were based on risk-taking behaviours frequently reported among

adolescents (European Monitoring Center for drugs and drug addiction – EMCDDA, 2019; Le Nez et al., 2015). They were presented in pseudorandomized order and the sections (adolescence vs. adulthood) were counterbalanced across participants.

Syllogistic reasoning task

The syllogistic reasoning task used in this study was based on the work of De Neys and Van Gelder (2009) and Steegen and De Neys (2012). All syllogisms had the same structure in that they were composed of two premises and one conclusion. The complete syllogism remained on screen until the participant provided a response.

Twenty-four syllogisms were presented to the participants, eight of which appealed to common beliefs (control content, e.g. 'All ravens have wings that allow them to fly'), eight appealed to beliefs about adolescents' risk-taking behaviours, with or without peers (adolescent-related content), and eight appealed to beliefs about adults' risk-taking behaviours, with or without peers (adult-related content) (see Table 1). The conclusions of the adulthood- and adolescence-related syllogisms were taken from the 16 statements used in the second section of the questionnaire, applying the first eight statements to adolescents and the last eight statements to adults for half the participants, and vice versa for the other half of the participants.

For all syllogisms, the conclusion could be 'high-believable' or 'low-believable.' For the control syllogisms, half of the conclusions were high-believable, namely, empirically valid (e.g. 'roses need water to grow'), and the other half were low-believable, namely, empirically invalid (e.g. 'airplanes carrying passengers are big cars'). The level of believability could be either *congruent* with logical validity for no-conflict syllogisms (both empirically and logically valid or both empirically and logically invalid) or *incongruent* with logical validity for conflict syllogisms (empirically valid but logically invalid or vice versa).

Given that risk taking has been shown to increase in the presence of peers (e.g. Chein et al., 2011), a conclusion of risky behaviour occurring in the presence of peers should be more believable than the same conclusion of such behaviour occurring in the absence of peers. Given that one of our goal was to study the belief that adolescents take more risks in the presence of peers, we classified 'risky behaviours in the presence of peers' as a *high-believable conclusion*, and 'risky behaviours in the absence of peers' as a *low-believable conclusion*.

We further classified syllogisms into two groups: no conflict and conflict. No-conflict syllogisms were those with *high-believable* and logically *valid* conclusions, or those with *low-believable* and logically *invalid* conclusions. Conflict syllogisms were those with *high-believable* and logically *invalid* conclusions, or those with *low-believable* and logically *valid* conclusions (see Table 1). In summary, there were four conflict and four no-conflict syllogisms for all three sets of content (i.e. each participant responded to 24 syllogisms in total). Participants first began with a practice block consisting of three syllogisms. They then responded to the 24 test syllogisms, presented in two blocks of 12 syllogisms, in pseudorandomized order.

For all three sets of content (control, adolescent-related and adult-related content), a *belief-bias index* was computed by subtracting the accuracy of the no-conflict syllogisms from that of the conflict syllogisms (e.g. Eliades et al., 2012). The higher the value of this index for a given participant was, the more the participant believed in the conclusions of the syllogisms. In other words, if participants believe that adolescents take more risks in the presence of their peers, they should endorse more often the high-believable conclusions compared to the low believable conclusions. Consequently, they should present a higher accuracy for the adolescent-related no-conflict syllogisms compared to the adolescents-related conflict syllogisms (see Table 1), demonstrating a belief bias for adolescents' syllogisms. On the other hand, we do not expect them to demonstrate a belief bias for adults' syllogisms. The comparison with common belief (control) syllogisms allows for an estimation of the magnitude of belief bias.

Data Analysis

First, to contrast adolescent's and adult's beliefs about risk taking in adolescence, compared to risk-taking in adulthood, we analysed risk-taking behaviours reported by adolescents and adults using the 16-item risk-taking scale. We computed a mean score by averaging the scores for each item. We compared adolescents' and adults' risk taking using a Student's *t* test. We also analysed both groups' perceptions about risk taking by computing a risk perception index. We averaged the mean reversed scores for cautiousness-related adjectives to the mean scores for risk-related adjectives (ranges from 0, extremely cautious, to 10, extremely risky). A three (Target: adolescence vs. adulthood vs. oneself) x two (Age Group: adolescents vs. adults) Analysis of Variance (ANOVA) was conducted to analyse variations in the risk perception index. Note that *p* values qualifying the main effects and interactions were obtained from post hoc pairwise comparisons using Tukey's HSD tests throughout the Results section.

Second, to determine whether adolescents' and adults' beliefs about adolescents' risk-taking are related to peer presence, we analysed the scores for the statements related to the effect of peer presence on risk taking. A two (Target: adolescence vs. adulthood) x two (Age Group: adolescents vs. adults) x two (Social Context: presence vs. absence of peers) mixed-design ANOVA was conducted on the statements' mean scores.

Third, we analysed the results from the syllogistic task, which was an indirect measure of beliefs. We computed a mean belief bias index by subtracting the accuracy for the no-conflict syllogisms from that for the conflict syllogisms (e.g. Eliades et al., 2012), for each type of content (control, adolescence related, and adulthood related). Note that a positive value indicates a higher level of belief bias. A two (Age Group: adolescents vs. adults) x three (Content: control vs. adolescence-related vs. adulthood-related) mixed-design ANOVA was conducted on the belief-bias index to examine to effect of the interaction between syllogism content and age group. For each of the analyses, we provided an estimate of the effect size, namely, the partial eta squared (η_p^2) for the ANOVAs and Cohen's *d* (*d*) for the post-hoc comparisons.

Results

Adolescent's and adult's beliefs about risk taking in adolescence compared to risk-taking in adulthood

Adolescents reported slightly more risk taking on the 16-item risk-taking scale ($M = 2.79$, $SD = 1.91$) than adults in their daily lives ($M = 2.25$, $SD = .88$), but the statistical comparison between the two means did not reach significance, $t(92) = 1.66$, $p = .10$, $d = .36$.

The three Target x two Age Group ANOVA conducted to analyse variations in the level of risk perception revealed a main effect of Target, $F(2,184) = 59.71$, $p < .001$, $\eta_p^2 = .39$, characterized by a perception of higher risk taking in adolescence ($M = 5.80$, $SD = 1.36$) compared to adulthood ($M = 4.36$, $SD = 1.23$), $p < .001$, $d = 1.12$ and a perception of higher risk taking in adulthood compared to oneself ($M = 3.69$, $SD = 1.42$), $p = .01$, $d = 0.51$.

In addition, while the ANOVA revealed no main effect of Age Group, $F(1,92) = 0.15$, $p = .70$, $\eta_p^2 = .00$, it revealed a significant Target x Age Group interaction, $F(2,184) = 10.73$, $p < .001$, $\eta_p^2 = .10$. The interaction was qualified by the fact that, while adolescents perceived adolescence to be a period of higher risk taking than adulthood ($M = 6.06$, $SD = 1.31$, and $M = 3.80$, $SD = 1.27$, respectively), $p < .001$, $d = 1.77$, adults rated adolescence and adulthood similarly ($M = 5.55$, $SD = 1.39$, and $M = 4.91$, $SD = 1.13$, respectively), $p = .28$, $d = 0.51$ (see Figure 1a.). In addition, while adolescents perceived their own level of risk taking ($M = 3.90$, $SD = 1.27$) to be equivalent to that of adults, $d = .08$, and to be lower than that of their peers (i.e. other adolescents), $p < .001$, $d = 1.69$, adults perceived themselves ($M = 3.48$, $SD = 1.65$) to be less risk taking than both adolescents and their peers (i.e. other adults), $p < .001$, $d = 1.37$ and $p < .001$, $d = 1.02$, respectively. Thus, adolescents and adults differed in their perceptions of adolescence-related risk taking, where adolescents perceived adolescence to be a period of greater risk taking than adulthood, but adults did not perceive a difference between adolescents' and adults' risk taking.

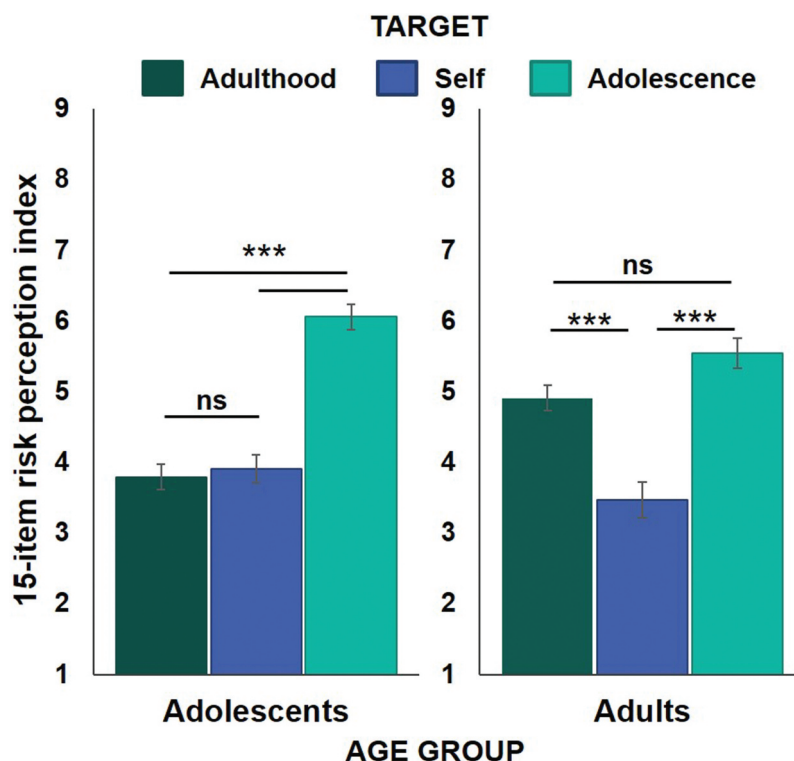


Figure 1. Average risk perception scale. *Note.* Average risk perception index for each target (adolescence, adulthood and self) and both age groups (adolescents and adults). *** $p < .001$; ns = not significant. Error bars represent standard errors of the means.

Adolescents' and adults' beliefs about adolescents' risk-taking related to peer presence

A two Target \times two Age Group \times two Social Context mixed-design ANOVA was conducted on the statements related to risk taking's mean scores. The analysis revealed that all main effects and interactions were significant (see the Supplementary Material for the presentation of all the effects). Because the two-way interactions and main effects were modulated by a three-way interaction between Age Group, Target, and Social Context, $F(1,92) = 12.58$, $p < .001$, $\eta_p^2 = .12$, we focus on the latter. While adults perceived peers to increase risk-taking behaviours during both adolescence and adulthood (Adolescence: $M_{\text{without peers}} = 4.12$, $SD = 1.35$ and $M_{\text{with peers}} = 5.27$, $SD = 1.98$, $p = .01$, $d = 0.69$; Adulthood: $M_{\text{without peers}} = 4.03$, $SD = 1.41$ and $M_{\text{with peers}} = 5.24$, $SD = 1.65$, $p = .01$, $d = 0.80$), adolescents perceived this effect of peers to be present only during adolescence ($M_{\text{without peers}} = 4.62$, $SD = 1.36$ and $M_{\text{with peers}} = 7.51$, $SD = 1.70$), $p < .001$, $d = 1.89$, and not during adulthood ($M_{\text{without peers}} = 4.48$, $SD = 1.78$ and $M_{\text{with peers}} = 5.28$, $SD = 1.97$), $p = .10$, $d = 0.43$ (see Figure 2). Thus, adults and adolescents did not differ in their perception of adults' risk taking, whether in the presence or in absence of peers. However, they differed in their perception of adolescents' risk taking, such that adolescents perceived their age group to take more risk than adults in the presence of peers.

Measuring implicitly adolescents' and adults' beliefs about risk taking in the presence of peers

The two Age Group \times three Content mixed-design ANOVA on the belief-bias index did not reveal a main effect of Age Group, $F(2,150) = 0.57$, $p = .45$, $\eta_p^2 = .01$, but revealed a main effect of Content, F

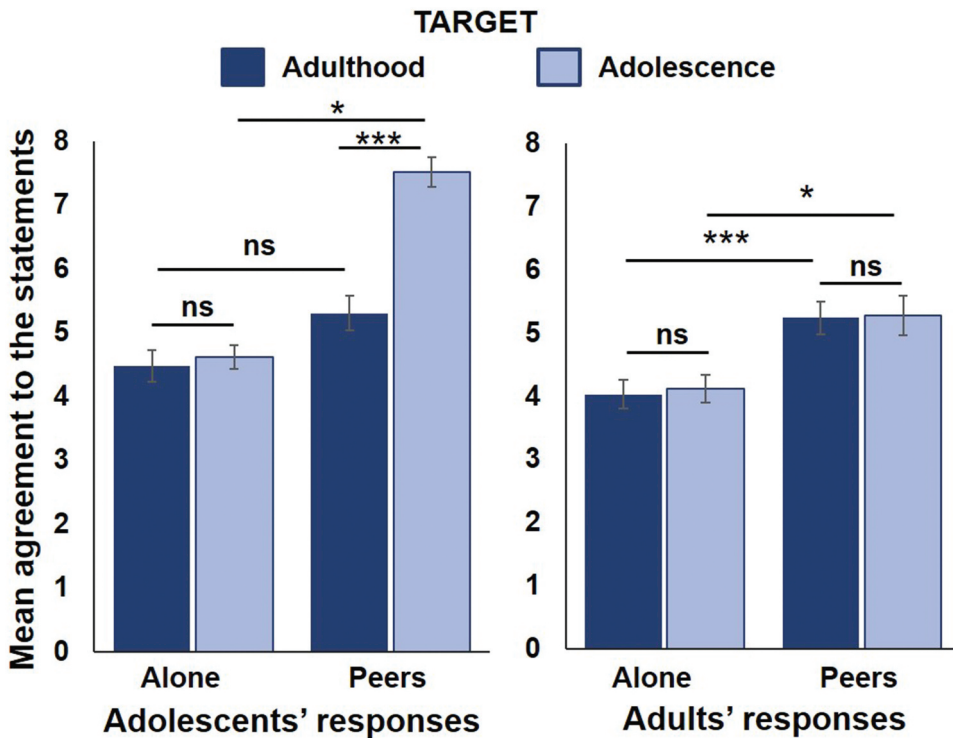


Figure 2. Mean agreement with statements relating to risk-taking behaviours in the absence or presence of peers. *Note.* * $p < .05$, *** $p < .001$. Error bars represent standard errors of the means

(2,172) = 74.15, $p < .001$, $\eta_p^2 = .46$ and a significant interaction between Age Group and Content, $F(2,172) = 3.85$, $p = .02$, $\eta_p^2 = .04$.

The interaction was qualified by the fact that, while adolescents demonstrated a larger belief bias for adolescent-related syllogisms ($M = 0.13$, $SD = .29$) than for adult-related syllogisms ($M = -0.04$, $SD = .32$), $p = .05$, $d = 0.56$, adults demonstrated similar levels of belief bias for adolescent- ($M = 0.01$, $SD = .34$) and adult-related syllogisms ($M = 0.05$, $SD = .30$), $p = .99$, $d = 0.13$ (see Figure 3). In both adolescent and adult groups, belief bias for control syllogisms was strong (respectively, $M = 0.53$, $SD = .30$, and $M = 0.43$, $SD = .44$) and higher than that for adolescent- and adult-related syllogisms ($ps < .001$; see Figure 3).

In the adolescent group, belief bias differed from zero for control syllogisms, $t(47) = 12.25$, $p < .001$, and for adolescent-related syllogisms, $t(47) = 3.10$, $p = .01$, but not for adult-related syllogisms, $t(47) = 1.08$, $p = .87$ (p values obtained using Holm-Bonferroni correction). In the adult group, belief bias differed from zero for control syllogisms, $t(40) = 6.35$, $p < .001$, but not for adolescent-related syllogisms, $t(40) = .23$, $p = .99$, or adult-related syllogisms, $t(40) = 1.05$, $p = .9$. The analysis of the proportion of participants who demonstrated a belief bias in the expected direction, no belief bias, or reversed belief bias for each age group and each type of content is reported in the Supplementary Material.

Discussion

Adolescence is believed to be a period of greater risk taking (compared to both childhood and adulthood, Casey et al., 2008), particularly in the presence of peers. Given that the beliefs people have about the expected behaviours in their social group can influence their own behaviour (Ciranka

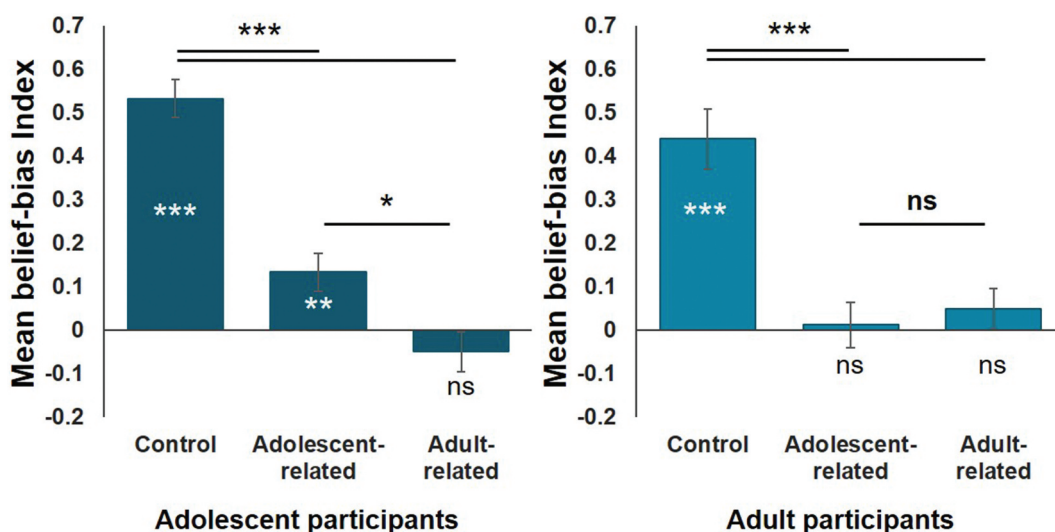


Figure 3. Mean belief bias index (and standard deviations) for each type of syllogism content (control, adolescence-related, and adulthood-related) and for each age group (adolescents and adults). Note. * $p < .05$, ** $p < .01$, *** $p < .001$. We compared the mean belief-bias indices to zero (one-sample t tests with zero as the test value, Holm-Bonferroni corrected). Error bars represent standard errors of the means.

& Bos, 2021), it is important to explore such beliefs. The present study shows that adolescents perceive adolescence as a period of higher risk taking, compared to adulthood, and this was especially true in the presence of peers. Such belief was not shared by adults.

Beliefs about risk taking during adolescence

Consistent with previous studies (Gross & Hardin, 2007), and in line with our hypothesis, adolescents were found to perceive adolescence as a period of higher risk taking. While adolescents' beliefs are in line with data showing an increase in risk-taking behaviours during adolescence (e.g. Boyer, 2006), such increase may only be marginal (e.g. Defoe, 2018; Romer et al., 2017). For the majority of individuals, adolescence takes place without major risk taking (such as substance abuse, sexually transmitted infection, pregnancy, or car accident-related death; see Willoughby et al., 2013, for a critical analysis of risk-taking behaviours). Accordingly, in the present study, adolescents' actual risk-taking behaviours did not differ significantly from those of adults. In addition, adolescents saw themselves as taking fewer risks than their peers, and their perceptions of themselves were in fact equivalent to their perceptions of adults. The discrepancy observed between adolescents' self-perception and their perception of their peers is in line with previous studies revealing an overestimation of the frequency of risky behaviours by others (Ciranka & Bos, 2021) and an exaggeration of adolescence-related stereotypes (Chan et al., 2012). This discrepancy may be the result of an exaggerated perception of adolescents' risk-taking propensity, due to the fact that adolescents associate their own developmental period with that of a few individuals who show exaggerated reckless behaviours (Romer et al., 2017). As a result, these reckless, more salient adolescents – who confirm the stereotype of adolescence as a period of storm (Arnett, 1999) – may be categorized as 'typical adolescents' when they are only extreme cases. Given the higher salience of reckless behaviours, the latter behaviours of their peers may be more easily remembered when adolescents are asked to evaluate risk taking during adolescence (Chan et al., 2012), resulting in a biased perception. These results may thus indicate that adolescents conform to a social norm that defines adolescence as a time of

increased risk taking while not perceiving themselves as risk takers. Such labelling could impact their perception of risk-taking behaviour, as expected for their age group, and thus contribute to increasing their actual risk taking (see Defoe et al., 2022 for a similar argument). Further studies may focus on the relationship between such labelling and actual risk-taking.

Contrary to our expectations, adult participants did not report adolescence to be a period of greater risk taking compared to adulthood. These results contrast with those of several previous studies (e.g. Gross & Hardin, 2007; Hines & Paulson, 2006). However, such studies were conducted using samples of young adults (approximately 21–22 y.o.), whereas in the present study, adult participants were aged between 30 and 60. The majority of adult participants (80.5%) also reported having children and/or teenagers of their own and were likely to have actual interactions with adolescents. It is possible that being a parent decreases the perception of adolescence-related risk-taking proneness and contributes to more balanced judgements. On the other hand, as the risk-taking norm seems to be exaggerated, adults' perception may be closer to reality, as it is influenced by their own children's risk-taking. Future studies should aim to disentangle an effect of age from an effect of parenthood to explain the discrepancy across studies.

Beliefs about the effect of peer presence on risk taking during adolescence

While adults perceived peers to increase risk-taking behaviours irrespective of age, adolescents perceived this detrimental effect of peers to be present only during adolescence and not during adulthood. Thus, contrary to our expectations, adults and adolescents differed in their perceptions of the effect of peer presence.

Such finding was obtained using both direct and indirect measures, respectively a questionnaire and a syllogistic reasoning task. When responding to the questionnaire, adults were equally prone to endorse statements in accordance with the belief of increased risk taking in the presence of peers, whether in adolescence or adulthood. As the direction of peer influence (i.e. risky vs. safe) depends on expectations about appropriate behaviours endorsed by one's group (Osmont et al., 2021; Tomova & Pessoa, 2018), such result may indicate that adult perception of peer influence on risk taking is the result of a nuanced understanding of social influences and of intersubject variability in adolescents' behaviours. These points should be further investigated in future studies.

On the other hand, adolescents endorsed this effect for adolescence only. In the syllogistic task, adolescents were more willing to consider a syllogism as valid when it was consistent with the belief that adolescents take risks in the presence of their peers (as opposed to in the absence of peers). Meanwhile, belief bias was not observed for adult-related syllogisms, indicating that the peer-presence effect only applies to adolescence. The present study shows that adolescents are biased by their beliefs about adolescence, even though the strength of this bias was weaker than for other control contents. These results contribute to a better understanding of adolescents' beliefs about risk taking, by indicating that adolescents believe peer presence to promote adolescent risk-taking, which is in line with a number of studies highlighting such influence (e.g. Blakemore, 2018; Chein et al., 2011; Osmont et al., 2022; Shulman, Harden, et al., 2016). Further studies might determine the impact of such belief on peer influence, that is whether this representation is related to an increase or a decrease of peer influence on adolescents' risk taking.

The use of an indirect measure confirmed the results obtained from the questionnaire and enabled us to avoid possible response biases such as social desirability (Vroling & de Jong, 2009, 2010). The syllogistic reasoning task may thus be usefully employed as a novel useful measure of beliefs, and might enable to explore the relation between such beliefs and peer influence on risk taking.

Limitations

One limitation of the present study lies in the characteristics of our sample, that is, the narrow age range among adolescents (16–18 y.o.) and the predominance of female participants. A future study

may cover a larger developmental period and involve a larger number of adolescents in order to study the influence of inter-individual differences on adolescents' risk-perception (e.g. sex and personality traits). We note, however, that while some studies reported more risk-taking in adolescent boys than girls, these differences only occurred in the presence of peers (de Boer et al., 2017; Defoe et al., 2020). Other experimental studies did not report that adolescents' gender modulated risk taking (e.g. Fryt et al., 2021, Gardner and Steinberg 2005; Harakeh & de Boer, 2019).

Second, the first part of this study relies mainly on self-report measures. This kind of measure may be subject to various biases, such as social desirability bias, and may not accurately reflect real-life behaviours. However, self-report measures remain a valuable tool to study real-life risk taking and may sometimes be better suited than experimental paradigms (Frey et al., 2017; Hertwig et al., 2019). Furthermore, we replicated one of our findings using an indirect measure (a syllogistic reasoning task), reinforcing the conclusions that can be drawn from the questionnaire data.

Finally, an exploration of the topic using open questions could be valuable for a deeper understanding of adolescents' definition of risk-taking behaviours, beyond experimental stereotypes, and of the underlying factors. Interestingly, when asked to determine what comes to their mind about 'risk taking', American adolescents predominantly reported educational risk behaviours (Skaar, 2021). Open question can also be a valuable tool to grasp cultural differences in risk behaviours (e.g. Kloep et al., 2009).

Conclusion

The present study shed light on adolescents' beliefs about risk taking and the influence of peers. Our results indicate that adolescents believe adolescence to be a period of heightened risk taking compared to adulthood and that they believe peer presence to promote this effect. Unlike adolescents, adult participants aged 30 to 60 years did not share these beliefs. These results indicate that adolescents have integrated unwritten social rules about the behaviours expected of themselves, namely, social norms that assume increased risk-taking at that age period (Tomova et al., 2021). The tendency to engage in risk-taking behaviour has been related to a greater tendency to explore unknown aspects of the environment, and to acquire one's own independence (see e.g. Do et al., 2020). Thus, risk taking can be seen as a crucial behaviour for building one's identity and autonomy. The adherence to a social norm that assumes risk taking – particularly in the presence of peers – to be correlative of adolescence, could be viewed as a process that reinforces adolescents' group affiliation. However, this perception may also contribute to a conflict between adolescents' self-representation (the self being seen as less risk taking) and the perception of the adolescent group. Defoe et al. (2022, p. 1) refers to Labelling theory by pointing out that 'caution is warranted when (inaccurately) labelling adolescents as the stereotypical risk-takers, because this can instigate a risk-taking identity in adolescents and/or motivate them to associate with risk-taking peers, which could in turn lead to maladaptive forms of risk-taking.'

Second, the use of a novel indirect measure, namely, a syllogistic reasoning task, confirmed the findings obtained using self-reports. To our knowledge, this is the first study to examine adolescents' beliefs using both a questionnaire and a classic syllogistic reasoning task. This type of paradigm may be useful to study specific beliefs without having to ask explicitly about them, and thus circumvent the biases associated with self-reports.

Third, this study mainly focused on negative risk-taking. Recently, a growing body of work has explored both negative and positive risk taking, the latter being defined as risks yielding to "potential benefits to adolescents' well-being without threatening their health and safety and that of those around them" (Duell & Steinberg, 2020, p. 1162). Adolescents' beliefs about such risk taking still have to be explored.

Implications

Conforming to perceived social norms can influence one's own behaviours. Studying adolescents' beliefs about risk-taking propensity can help us understand the heightened risk-taking behaviours observed in

this developmental period. Part of this effect could be the result of conformism to social expectations. Better knowledge of adolescents' beliefs can contribute to the development of interventions that can help them become more competent decision-makers and more able to avoid social conformism. This study lays the ground for further studies evaluating the impact of beliefs on adolescents' risk-taking propensity, both alone and in the presence of peers.

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MH conceived of the study, participated in its design and coordination, performed the measurement and the statistical analysis and drafted the manuscript; AO participated in the design of the study and interpretation of the data and helped to draft the manuscript; J-LT participated in interpretation of the data and helped to draft the manuscript; MC participated in the design of the study and the interpretation of the data and helped to draft the manuscript; SC SC conceived of the study, participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

Ethical approval

The research was pre-approved by the protection data officer of the institution.

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