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Younger adults are more prosocial than older adults in economic decision making results from the give and take game

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ABSTRACT

The present study was designed to investigate the disadvantageous and advantageous inequity aversion of young and older adults in situations which allowed them to maximize or minimize payoff inequalities. Given the very limited evidence regarding an actual age-related effect on inequity aversion, the purpose of this study was to examine this question using an economic game, "the Give-and-Take Game", which is able to circumvent certain limitations of the Ultimatum Game, to evaluate inequity aversion (i.e., a same behaviour which can be induced by opposite motivations: *prosocial* vs. *pro-self* vs. *altruistic* orientations). In the "Give-and-Take Game", a sum of money was randomly distributed between the participant and a dummy player. These distributions created monetary inequalities, advantageous either for the participant (to examine advantageous inequity aversion) or for the other player (to examine disadvantageous inequity aversion). Different response options were proposed to the participants to either maximize or minimize payoff inequalities between the players. This procedure not only allowed to differentiate individual's profiles with more *prosocial* vs. *pro-self* vs. *altruistic* orientations, but also to examine age-related effects on these profiles. The results showed that older adults showed a more important *pro-self* orientation compared to their younger counterparts. They more frequently selected the options which maximized their own payoffs and were less averse to advantageous inequity compared to young adults. In contrast, young adults showed a similar level of advantageous and disadvantageous inequity aversion. Older adults focused on the economic and competitive dimension of the game, which may have motivated them to maximize their own payoffs. Conversely, young adults took into account the social dimension of the game, focusing on a fair monetary distribution.

1. Introduction

In the past decades, a number of studies have agreed that prosociality and altruism generally increase with age, although the reasons why are not yet well understood [1–5]. In the financial domain, according to the social value orientation (SVO) theory [6,7], prosocial individuals tend to maximize their financial resources both for themselves and others, and to minimize differences between financial resources for themselves and others. Altruistic individuals are motivated to help those who are in need. These individuals are willing to sacrifice their financial resources to help others increase their payoff. By contrast, pro-self individuals tend to maximize their

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financial resources without worrying about the others' resources. In the field of psychology and experimental economics, this kind of behaviours have been extensively studied using social situations among competing players in the theoretical framework of Game theory [8]. Fairness-related decision making and inequity aversion are examined using economic and behavioural games such as the Ultimatum game [9] (UG) and the Dictator game [10] (DG), for example. However, the studies which have used this kind of games to investigate the effects of age on fairness-related decision making and inequity aversion reported particularly inconsistent results, as we will review below [11–16]. In view of these contradictory results in the literature, the present study proposes to investigate disadvantageous and advantageous inequity aversion and to identify whether social value orientation profiles (i.e., Pro-self, Prosocial, Altruistic), according to the respondents' responses in the game, may differ as a function of chronological age in young and older adults.

In contradiction to predictions from standard economic theory and the classical theory of games, a substantial body of literature in psychology and experimental economics has shown that adults engage in some degree of wealth redistribution to achieve a more equitable distribution of financial resources [17–20]. To account for these results, theoretical models of social preferences assume that people are motivated by other-regarding preferences and are concerned by both the well-being of their peers and fairness (for a review see Ref. [21]). Among these models, the inequity aversion model has drawn much attention [22]. This model assumes that people are both concerned about their own payoffs, and others', and that they would sacrifice their payoffs in order to avoid unfair treatment. This occurs not only when the inequity is not in their favour (i.e., disadvantageous inequity aversion), but also when it is (i.e., advantageous inequity aversion).

The Ultimatum Game (UG) is a bargaining game [9]. In Experimental Economics, Psychology and Neuroscience, the UG has been one of the most widely used paradigms to investigate fairness-related decision making and inequity aversion [23–25] compared to other paradigms (e.g., DG [10], Third-party punishment game [26], Inequity game [24], Public Good Game [27]). In this game, two players bargain over the division of a sum of money. The *proposer* is given a fixed amount of money (e.g., €10) and is required to share it with the *responder*. If the responder accepts the share offered by the proposer, the sum is divided accordingly, but if the responder refuses the offer, all the money is lost and neither of the players receives money. Based on the assumption that the responder will accept any offer [9,28], classical game theory predicts that the proposer will offer the responder the smallest non-zero amount possible (e.g., €1 out of €10). However, a substantial body of literature contradicts the predictions of this classical game theory by showing that responders reject offers of less than 20% of the total amount of money and that proposers generally offer about 40% [29,30].

According to the inequity aversion model [22], inequity aversion would drive responders to reject unfair offers to avoid getting a lower payoff than the proposer (i.e., disadvantageous inequity). Inequity aversion would also drive the proposers to offer fair shares to the responder in order to avoid getting a too high payoff (i.e., advantageous inequity). Nevertheless, inequity aversion appears to vary depending on individuals' sociodemographic characteristics, such as culture [31], gender [32,33], or even social status [34]. Given the reported literature on the effects of age on prosocial behaviour and fairness [1,3–5], differences would also be expected between young and older adults in inequity aversion. However, as reported below, few studies have examined this question so far and their results are remarkably mixed.

In the context of the UG, two studies have examined age differences relating to proposers' behaviour. One study [11] reported that older proposers offered significantly more generous offers than younger proposers, suggesting that older adults are more averse to advantageous inequity than younger ones. However, another study has not found any age-related differences in advantageous inequity aversion [12]. Furthermore, five other studies have examined age-related differences in responders' rejection rates, which have also led to a mixed pattern of results. Two of them has not found any age-related difference for disadvantageous inequity aversion [11,12], while two others have found out that older responders rejected unfair offers more often compared to younger responders, suggesting that older adults were more averse to disadvantageous inequity than younger adults [13,14]. In the last studies, the opposite result was observed: older responders rejected fewer unfair offers compared to younger ones, suggesting that older adults are less averse to disadvantageous inequity than younger adults [15,16].

Moreover, so as to examine age differences in fairness-related decision making, three studies have used another game, namely the DG [14,35,36]. This game is similar to the UG, except that the responder must accept the amount offered by the proposer (i.e., the dictator). This economic game thus allows to examine advantageous inequity aversion (i.e., that of the dictator) but does not allow to examine disadvantageous inequity aversion (i.e., that of the responder) as in the UG. Two of the mentioned studies have not found any age-related effect on decision-making [14,36]. The third one, which used a modified DG by inducing empathy into dictators, has found out that older participants offered significantly more generous offers than younger proposers [35]. As it was the case for the UG, the results are also remarkably mixed here.

To date, no definite theoretical explanation has been proposed to understand these contradictory results in the literature. On one hand, the fact that older adults would be more likely to accept unfair offers than their younger counterparts could result in two distinct motivations: 1) a strategic behaviour in order to increase their gains (i.e., *pro-self* behaviour), or 2) a generous behaviour, to leave more for others than for themselves (i.e., *altruistic* behaviour). Similarly, the fact that older adults tend to reject unfair offers more often compared to younger people could be interpreted in two opposite ways: 1) as a greater aversion to inequity, which results in the decision to reduce their own financial resources and those of others in order to achieve a more equitable outcome between individuals (i.e, *prosocial* behaviour) or 2) as a greater desire to prevent the competitor from maximizing his/her gains (i.e, *competitive* behaviour [37,38]). Thus, we can see that the behaviour which consists in rejecting unfair offers can give rise to multiple interpretations on the motivation associated with this behaviour (i.e., Prosocial, Pro-self and Altruistic). On the other hand, the Socioemotional Selectivity Theory [39] has been proposed to better explain the fairness-related decision making of older adults compared to younger ones in some studies using such games [11,12]. According to these studies, aging would lead to a shift into motivation, from self-related and instrumental goals to emotionally fulfilling social goals, which may be associated with age-related improvements in the regulation of emotions and an increase in prosocial tendencies. Conversely, there is no specific theory explaining why, in some studies [15,16], older adults would more often tend to accept unfair offers compared to younger adults. This specific behaviour could be in accordance with the classical game theory [8,9,40] according to which each individual should accept every share which is offered to them rather than nothing, in order to maximize their gains. This economic decision is considered as strategic and rational.

Given the very limited evidence reported above concerning an actual age-related effect on inequity aversion, the purpose of the present study was to examine this question using a modified economic game, the "Give-and-Take Game" (inspired by experimental protocols [41,42]), which is able to circumvent the methodological drawbacks mentioned below. Indeed, although the DG and the UG have been widely used, they have certain limitations in evaluating inequity aversion. First, the fair proposer's offers can be influenced by one of the two opposing motivations: a prosocial motivation which reflects a preference for fairness (i.e., advantageous inequity aversion, see Ref. [22]) or a strategic motivation which leads the proposer to use instrumental fairness to avoid the responder from rejecting his/her offer, aiming at maximizing his/her gain [43–46]. One must note that the fair proposer's offer may also be the result of a combination of prosocial-based and strategic motivations [44]. Second, and similarly, different motivations can lead the responders to reject unfair offers: real disadvantageous inequity aversion [6] or jealousy-based motivations [46]. Thus, in the DG and the UG, different motivations can lead the players (i.e., proposers and responders) to adopt the same behaviour (i.e., to propose fair offers or to reject unfair offers), and those different motivations cannot be disentangled by these protocols.

In order to limit this methodological bias in examining inequity aversion in the present study, we have developed a modified game, the "Give-and-Take Game," which 1) reduces strategic behaviours (i.e., instrumental fairness) because the participants' economic decisions cannot be rejected by the other player and 2) reduces the number of potential/possible motivations associated with the same behaviour (i.e., *Pro-self, Prosocial, Altruistic*). Finally, the design of our game allows studying, in the same paradigm, disadvantageous and advantageous inequity aversion, without the participants needing to play both roles (i.e., proposer/responder). In this game, the computer makes random inequitable monetary distributions between two players (i.e., the participant and a dummy player). These distributions create monetary inequalities, either advantageous for the participant (i.e., to examine advantageous inequity aversion) or advantageous for the dummy player (i.e., to examine disadvantageous inequity aversion). Participants can reapportion the distributions by choosing from the following three options: "Accept", "Equilibrate" or "Reverse" the monetary distributions made by the computer. These options allow the participants to either a) minimize the difference between their payoff and the other player's payoff (i.e., *Prosocial orientation*), b) maximize their own payoff (i.e., *Pro-self orientation*), or c) maximize the payoff of the other player (i.e., *Altruistic orientation*) (see Ref. [7]).

In view of the contradictory results in the literature concerning age-related differences on inequity aversion and the methodological issues linked to the UG to examine this question, we propose three competing hypotheses to investigate disadvantageous and advantageous inequity aversion and identify a social value orientation profile (i.e., *Pro-self, Prosocial, Altruistic*) in young and older adults, using the "Give-and-Take Game".

Hypothesis 1. If older adults tend to be more Pro-self-oriented compared to younger adults, they would significantly more often select the options which maximize their own monetary payoffs when they receive both advantageous and disadvantageous inequity distributions. Such a result would suggest that older participants are less averse to advantageous inequity than younger adults.

Hypothesis 2. By contrast, if older adults tend to be more Prosocial orientated compared to younger adults, they would significantly more often select the options which maximize both their own and the other player's payoffs when they receive either advantageous or disadvantageous inequity distributions. Such a result would suggest that older participants are more averse to advantageous inequity than younger adults.

Hypothesis 3. Finally, if older adults tend to be more Altruistic orientated compared to younger adults, they would significantly more often select the options which maximize the payoffs of the other player when they receive advantageous inequity distributions, suggesting that older participants are less averse to disadvantageous inequity.

2. Materials and Method

2.1. Participants

The sample size was established on the basis of several studies which have examined age-related differences in inequity aversion [11–13,15,16]. Therefore, we determined the required sample size by an a-priori power analysis using G*Power [47,48]. Based on an effect size of w = 0.30 with α set at 0.05 and a power of .80, a minimum total sample size of 50 participants was required. We chose to increase this sample by eight participants to take into account possible technical problems of data recording and subject rejections.

Table 1 presents the characteristics of the two groups of participants. Specifically, fifty-eight volunteers were recruited to

Table 1
Characteristics of the two groups of participants.

	Young Adults (N = 29)	Older Adults (N = 29)
Age (years)	20.76 ± 2.95	67.93 ± 5.40
Gender (F/M)	16/13	16/13
Education (years)	13.59 ± .98	13.90 ± 3.11
Median Income (euros)	1 = €0 and €568	4 = €1704 and €2271

participate in this experiment, including 29 young participants (16 females, age range 18–27 years old) who were all students at the departments of Biology, Law, Psychology and Physics at the University of Albi (France), and 29 older participants who were recruited from charities, associations and conferences organized by the University (16 females, age range 60–81 years old). Young adults and older adults reported a similar number of years of education ($U = 194.5$, $z = -1.18$, $p = .238$). The two age groups had different financial incomes ($U = 6$, $z = -6.80$, $p < .0001$). Younger and older adults were in self-reported good-to-excellent health. Older adults had a rather high level of education, they were socially active and were living independently at home. They all completed the Mini Mental State Examination [49] (MMSE), and none scored below 28/30. All the participants had normal or corrected-to-normal vision and had no history of neurological or psychiatric disorders.

3. Ethics statement

The study was conducted in accordance with the *Declaration of Helsinki* (2013) and approved by the ethics committee of the laboratory Sciences de la Cognition, Technologie, Ergonomie (SCoTE), Institut National Universitaire Champollion n° 2018-01.

All the participants were informed of their rights and provided their written informed consent to participate in the study. For the purpose of the study, the participants were told that they would be paid a percentage of what they won during the game, calculated on the basis of randomly chosen trials. The participants were also informed that the minimum gain they could obtain in the game was 1 euro and that all the participants would be paid at the end of the study when all the participants have completed the task. At the end of the study, all the participants were fully debriefed, paid and thanked. For ethics and fairness principles, all the participants received the same amount of €5. This procedure is often applied in studies using the UG [50,51].

3.1. Task and procedure

Participants played a novel game, the “Give-and-Take Game”, inspired from the UG and inspired by experimental protocols [41,42]. In this game, the participants were led to think that they formed a pair with the same anonymous player the entire time, who was a dummy player. No information was given on the age and the gender of the other player. Before beginning the game, all the participants received written instructions about the rules. They were told that the computer would divide €10 randomly between the two players as in the literature mentioned in the introduction [11,14]. For example, the computer could allocate €1 to one player and €9 to the other one. The participants were told that they could reapportion the distributions done by the computer by choosing from the following three options: (1) Accept: the participants accept the split proposed by the computer; (2) Equilibrate: the distribution becomes €5 for each player (i.e., equity); (3) Reverse: the participants inverse the distribution between the players. For example, assuming that the computer attributed €1 to the participant and €9 to the dummy player. Then, if the participant reverses the distribution, they get €9 and

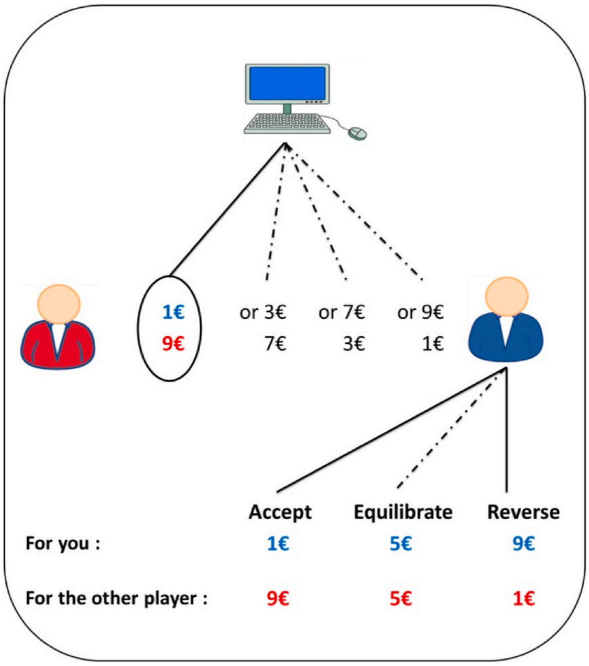

Fig. 1. Schematic representation of the game. Illustration of a typical trial, in which the computer attributed €1 to the participant (blue) and €9 to the dummy player (red). The three options (i.e., Accept, Reverse and Equilibrate) were paired with one alternative option per trial. In this illustrated trial, the participant was presented with the option: Accept or Reverse the distribution (solid lines). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

the dummy player gets €.1 The participants were presented with only two options on any given trial; each option (i.e., Accept, Equilibrate or Reverse) was paired with one alternative option per trial, for a total of three combination pairs (i.e., "Accept or Reverse", "Accept or Equilibrate", "Equilibrate or Reverse"; see Fig. 1). This forced choice procedure allowed to differentiate individual profiles with more *Prosocial vs. Pro-self vs. Altruistic orientations* (see Table 2) and to calculate a Payoff Ratio Scale conceptualized as a continuum which reflects the amount of his/her own resources the participant is willing to sacrifice to benefit another (see section Results).

Participants were told that each member of the pair was performing the task separately and that they both would be paid according to the options that they chose (i.e., "Accept", "Reverse", "Equilibrate"). More specifically, they were told that each member of the pair would receive a percentage of randomly chosen trials: 1) on the amount that they chose to take in the game and 2) on the amount that their pair gave them. No additional instruction was given to the participant before starting the game.

During the game, participants were comfortably seated 70-cm away from a computer screen. The study was administered on a computer, using OpenSesame© software [52]. As depicted in Fig. 2, every trial started with a white fixation cross on a black screen for 1000 ms. Then, the distributions proposed by the computer were displayed on the screen (white font colour [Calibri, size 32] on a black background) and consisted of two rows. The first row indicated the amount given to the participant (e.g., "for you: €1"); the second row indicated the amount given to the dummy player (e.g., "for the other player: €9"). Below the distributions, a blue square and a green square were displayed on the screen, containing the options of the participant for any given trial (e.g., Accept or Reverse the distribution). Participants were instructed to press the colour key (i.e., blue or green) to select the option displayed respectively in the blue square (e.g., Accept) or in the green square (e.g., Reverse). Each response was followed by a 200-ms black screen (see Fig. 2).

The experimental session consisted of one block of 144 trials, comprising two conditions of 72 trials each. In the disadvantageous inequity distribution condition, participants received disadvantageous distributions compared to the dummy player (36 trials of €1/€9 and 36 trials of €3/€7); while in the advantageous inequity distribution condition, participants received advantageous distributions compared to the dummy player (36 trials of €9/€1 and 36 trials of €7/€3). For each condition, 24 trials were presented with each of the three combination pairs (i.e., "Accept or Reverse", "Accept or Equilibrate", "Equilibrate or Reverse"). The order of trial presentation was randomized across the block. Thus, 12 identical trials were presented to the participants for each type of distribution-combination (i.e., €1/€9 Accept or Reverse; €1/€9 Accept or Equilibrate; €1/€9 Equilibrate or Reverse; €3/€7 Accept or Reverse; €3/€7 Accept or Equilibrate; €3/€7 Equilibrate or Reverse; and so on for the opposite distributions; e.g., €9/€1 and €7/€3). Note that the choice of the number of trials in the present study was based on studies using similar protocol and statistical analyses (see Refs. [13,16,23,51,53]).

Before starting the experiment, so as to ensure that the participants understood it well, the latter took part in a short training session consisting of 12 trials, identical to those used in the experimental session.

If the participants are pure Altruists (first row), they would always select the options which maximize the payoffs of the other player (i.e., their Payoffs Ratio = 0.43). So, in the "Equilibrate or Accept" Combination Pair, they would choose the "Equilibrate option" in the Advantageous distributions, and the "Accept option" in the Disadvantageous distributions. In the "Reverse or Equilibrate" Combination Pair, they would choose the "Reverse option" in the Advantageous distributions, and the "Equilibrate option" in the Disadvantageous distributions. Finally, in the "Reverse or Accept" Combination Pair, they would choose the "Reverse option" in the Advantageous distributions, and the "Accept option" in the Disadvantageous distributions. The same rationale is presented for a pure Prosocial orientation (i.e., to minimize the difference between their payoff and the other player's payoff) and for a pure Pro-self orientation (i.e., to maximize their own payoff) respectively in the second and third rows.At the end of the experiment, the participants were asked to respond to five questionnaires.

"Belief about the other player" Questionnaire. "Did you believe you were playing this game against a real person?" ("YES" or "NO"). One hundred percent of the participants answered "YES". Although we cannot exclude that they responded to the question out of social desirability, this question allowed us to know if some participants should be excluded from the statistical analysis because they would have detected deception.

"Personal Income" Questionnaire. "Your monthly income is between (1 = €0 and €568; 2 = €569 and €1135; 3 = €1136 and €1703; 4 = €1704 and €2271; 5 = more than €2271)?"

"Perception Bias" Questionnaire. "Do you think that the computer made rather favourable distributions for (1 = me / 2 = the other player/3 = identical for me and for the other player)?"

"Declared Social Value Orientation" Questionnaire. We asked the participants to declare their social value orientation, which corresponds to their perceived preference about how they allocated the money between themselves and the other player. "Did you more often want to increase (1 = my payoffs; 2 = the other player's payoffs; 3 = both my payoffs and those of the other player)?" Response 1 is associated with a *pro-self orientation*, response 2 with an *altruistic orientation* and response 3 with a *prosocial orientation*.

Table 2
The game options selected according to an altruistic, prosocial and pro-self orientation.

	"Equilibrate or Accept" Combination Pair	"Reverse or Equilibrate" Combination Pair	"Reverse or Accept" Combination Pair	Payoffs Ratio (Participant Payoff sum/ dummy player Payoff sum)
Altruistic orientation	Equilibrate: AD Accept: DD	Reverse: AD Equilibrate: DD	Reverse: AD Accept: DD	= 0.43
Prosocial orientation	Equilibrate: AD Equilibrate: DD	Equilibrate: AD Equilibrate: DD	Accept/Reverse: AD Accept/Reverse: DD	= 1
Pro-self orientation	Accept: AD Equilibrate: DD	Equilibrate: AD Reverse: DD	Accept: AD Reverse: DD	= 2.33

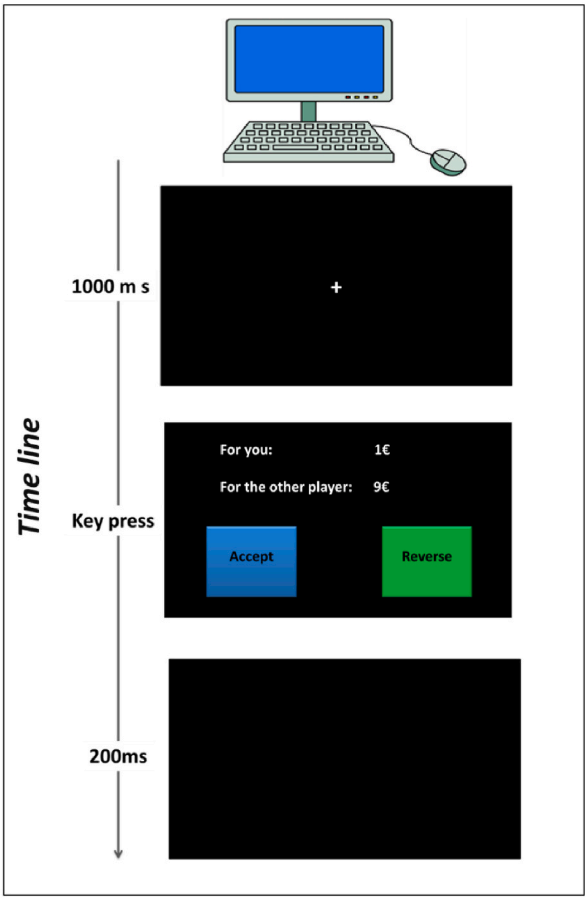

Fig. 2. Time course of one trial (see text for detailed description).
Note. AD: Advantageous distributions, DD: Disadvantageous distributions.

Open Questionnaire. We asked the participants to explain why they more often wanted to increase their own payoffs or the other player's payoffs or both their payoffs and those of the other player (i.e., pro-self, altruistic or prosocial).

Overall, the experimental session lasted around 45 min. At the end, the participants were fully debriefed, paid and thanked.

3.2. Statistical analyses

The first analysis aimed at examining the options chosen by young and older adults according to the three combination pairs in order to assess their advantageous and disadvantageous inequity aversion. The data collected were in the form of binary responses on monetary distributions, for each of the three combination pairs (i.e., "Accept or Reverse"; "Accept or Equilibrate"; "Equilibrate or Reverse"). The data for each combination pair were analyzed separately, using binary logistic regression with repeated-measures, implemented with generalized estimating equation [54] (GEE) using IBM SPSS Statistics (IBM Corp., 2012), with: Condition (disadvantageous inequity distributions vs. advantageous inequity distributions) as a within-participants factor, Age (younger adults, older adults) as a between-participants factor, and Income as a covariate factor (because of differences in incomes between younger and older participants). All reported *p*-values are Bonferroni-corrected for multiple comparisons. This analysis takes into account the correlation of responses within subjects, and produces a chi-squared statistic (χ^2), an odds ratio (OR) and its 95% confidence interval (CI), and a *p*-value. The odds ratio represents the change in probability of an event (in this case, the chosen option: "Accept/-Reverse/Equilibrate") occurring with a change in condition (disadvantageous distributions, advantageous distributions).

Second, we conducted complementary analyses on the number of options chosen by the participants (i.e., "Equilibrate", "Reverse" and "Accept") among all the trials (i.e., on the three combination pairs: "Accept or Reverse"; "Accept or Equilibrate"; "Equilibrate or Reverse"). These analyses examined whether young and older adults differently chose the pro-self, prosocial or altruistic options depending on the type of distributions they received (i.e., advantageous, disadvantageous). The data for each condition (i.e., disadvantageous inequity distributions, advantageous inequity distributions) were analyzed separately, using linear regression with repeated-measures, implemented with generalized estimating equation (GEE), with the Options ("Accept", "Reverse", "Equilibrate") presented as a within-participants factor, and Age (younger adults, older adults) as a between-participants factor. All reported *p*-values are Bonferroni-corrected for multiple comparisons. This analysis takes into account the correlation of responses within subjects, and produces a chi-squared statistic (χ^2) and a *p*-value.

Third, a Mann-Whitney *U*test was used to compare the Payoff Ratio between young and older participants to assess whether they behaved in a more prosocial, altruistic or pro-self manner.

Fourth, we used the Freeman-Halton extension of Fisher's exact test to examine the Declared Social Value Orientation questionnaire depending on the age group, in order to examine their explicit motivation regarding the monetary distributions between them and the other player (i.e., Pro-self, Prosocial or Altruistic orientation).

Fifth, we conducted bivariate Spearman correlations between the Payoff Ratio and the Declared Social Value Orientation score, in order to examine if the participants' explicit motivation was consistent with their behaviour in the "Give-and-Take Game".

Finally, we used the Freeman-Halton extension of Fisher's exact test to analyse the Perception bias questionnaire which could have explained a difference in behaviour in the game between young and older adults.

4. Results

4.1. Comparisons between "reverse or equilibrate" combination pair

The analyses revealed a significant main effect of Age [b = −1.49, Wald χ^2 (1) = 5.38, *OR* = 0.32, 95% CIs 0.26–0.39, *p* = .020], the fact of younger decreased the probability of reversing the distributions (M = 9.70%, SD = 6.58) compared to the fact of being older (M = 25.22%, SD = 10.04). There was a significant main effect of Condition [b = −1.80, Wald χ^2 (1) = 29.45, *OR* = 0.30, 95% CIs 0.24–0.38, $p < .0001$], indicating that the probability of reversing the distributions in the advantageous inequity condition was lower (M = 9.38%, *SD = 3.61*) compared to the disadvantageous inequity condition (M = 25.50%, *SD = 8.08*). The analysis also revealed a significant Condition × Age interaction [*b* = 1.59, Wald χ^2 (1) = 5.58, *p* = .018]. As can be seen in Fig. 3a, the probability to reverse the distributions was significantly greater when older adults received disadvantageous inequity distributions (*M* = 40.37%, *SD = 8.90*) compared to younger adults (*M* = 10.63%, *SD = 5.24, OR* = 5.69, 95% CIs 4.28–7.57, *p* = .009) and compared to their advantageous inequity distributions (*M* = 10.06%, *SD = 2.90, OR* = 6.06, 95% CIs 4.53–8.09, *p* = .048). In contrast, no difference was found when older adults received advantageous inequity distributions (*M* = 10.06%, *SD = 2.90*) compared to younger adults (*M* = 8.76%, *SD = 5.24, OR* = 1.16, 95% CIs 0.81–1.67, *p* = 1). Finally, no significant difference was found when younger participants received advantageous inequity distributions (*M* = 8.76%, *SD = 5.24*) compared to disadvantageous inequity distributions (*M* = 10.63%, *SD = 4.19, OR* = 0.80, 95% CIs 0.57–1.15, *p* = 1). (See the results of additional analysis for the distributions €1/€9; €3/€7; €7/€3 and €9/€1 in the Supplementary Materials: Table S1; Fig. S1; Fig. S2).

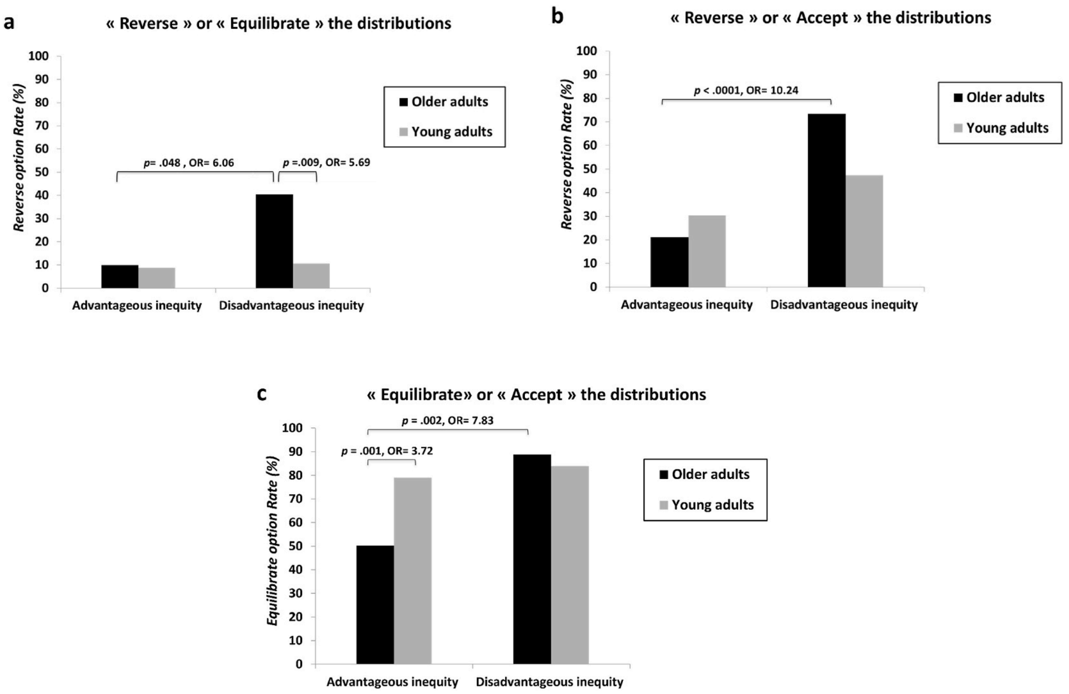

Fig. 3. Choice rates as a function of the three combination pairs. The participants had the choice between two options for each combination pair: (a) "Reverse" or "Equilibrate" the distributions. (b) "Reverse" or "Accept" the distributions. (c) "Equilibrate" or "Accept" the distributions.

4.2. Comparisons between "reverse or accept" combination pair

The analysis has not revealed any main effect of Age [b = −1.11, Wald χ^2 (1) = 2.01, *OR* = 0.70, 95% CIs 0.60–0.82, *p* = .157], but a significant main effect of Condition [b = −2.33, Wald χ^2 (1) = 25.61, *OR* = 0.22, 95% CIs 0.19–0.27, *p* < .0001], revealing that the probability of reversing the distributions in the advantageous inequity condition was lower (M = 25.65%, SD = 7.73) compared to the disadvantageous inequity condition (*M* = 60.34%, SD = 8.27). The analysis also revealed a significant Condition × Age interaction [*b* = 1.59, Wald χ^2 (1) = 6.13, *p* = .013]. As for the previous combination pairs comparison and as can be seen in Fig. 3b, the Condition effect was significant only for the older participants, not for the younger ones. Thus, the probability to reverse the distributions was greater when older adults received disadvantageous inequity distributions (*M* = 73.28%, SD = 7.65) compared to advantageous inequity distributions (*M* = 21.24%, SD = 6.88, *OR* = 10.24, 95% CIs 8.00–13.12, *p* < .0001). In contrast, no significant difference was found when younger participants received disadvantageous inequity distributions (*M* = 47.41%, SD = 7.91) compared to advantageous inequity distributions (*M* = 30.35%, SD = 7.08, *OR* = 2.09, 95% CIs 1.67–2.60, *p* = .21). (See the results of additional analysis for the distributions €1/€9; €3/€7; €7/€3 and €9/€1 in the Supplementary Materials: Table S2; Fig. S3; Fig. S4).

4.3. Comparisons between "equilibrate or accept" combination pair

The analysis revealed no main effect of Age [b = −0.16, Wald χ^2 (1) = 0.057, *OR* = 1.93, 95% CIs 1.61–2.30, *p* = .81], but a significant main effect of Condition [b = −2.062, Wald χ^2 (1) = 21.578, *OR* = 3.46, 95% CIs 2.86–4.18, *p* < .0001]. There was a higher probability of equilibrating the distributions in the disadvantageous inequity condition (M = 86.35%, SD = 4.34) compared to the advantageous inequity condition (M = 69.6%, SD = 9.26). The analysis also revealed a significant Condition × Age interaction [*b* = 1.74, Wald χ^2 (1) = 8.07, *p* = .005]. As can be seen in Fig. 3c, unlike the younger participants (for whom there was no significant effect of Condition), the probability to equilibrate the distributions was significantly greater when older adults received disadvantageous inequity distributions (*M* = 88.79%, SD = 3.92) compared to advantageous inequity distributions (*M* = 50.28%, SD = 9.97, *OR* = 7.83, 95% CIs 5.93–10.35, *p* = .002). Moreover, in the advantageous inequity distributions condition, the probability to equilibrate the distributions was significantly higher for younger participants (*M* = 79.02%, SD = 7.09) compared to older participants (*M* = 50.28%, SD = 9.97, *OR* = 3.72, 95% CIs 2.94–4.71, *p* = .001). In contrast, in the disadvantageous inequity distributions condition, no significant difference was found between older (*M* = 88.79%, SD = 3.92) and younger participants (*M* = 83.90%, SD = 4.74, *OR* = 1.52, 95% CIs 1.11–2.07, *p* = 1). (See the results of additional analysis for the distributions €1/€9, €3/€7, €7/€3 and €9/€1 in the Supplementary Materials: Table S3; Fig. S5; Fig. S6).

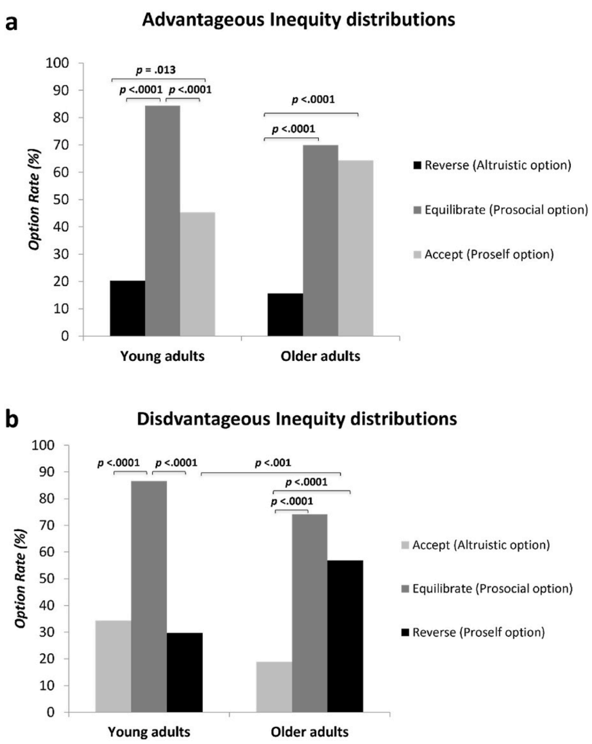

Fig. 4. Choice rates as a function of the frequency of an option (i.e., "Equilibrate", "Reverse" and "Accept") are selected from all available trials (each option's rate is out of 100%): (a) Results for the Advantageous inequity distributions condition; (b) Results for the Disadvantageous inequity distributions condition.

The next two analyses examined whether the participants more often chose the pro-self, prosocial or altruistic option depending on the type of distributions (i.e., advantageous, disadvantageous). The presented results report the total proportion of choice of an option (e.g., "Equilibrate") in all the trials which involved this option.

4.4. Comparisons between the three options in the advantageous inequity distributions condition

The analysis revealed a significant main effect of Options [b = 12, Wald χ^2 (2) = 273.42, $p < .0001$]. In the Advantageous inequity condition, the "Equilibrate Option" (M = 77.16%, SD = 6.07) was more often chosen than the "Accept Option" (M = 54.85%, SD = 10.01); which was more often chosen than the "Reverse Option" (M = 18%, SD = 8.88). The analysis also revealed a significant Options × Age interaction [b = 11.38, Wald χ^2 (2) = 8.08, p = .018]. As can be seen in Fig. 4a, the younger participants more often chose the "Equilibrate Option" (M = 84.33%, SD = 5.62) compared to the "Accept Option" (M = 45.33%, SD = 9.47, $p < .0001$) and the "Reverse Option" (M = 20.33%, SD = 9.71, $p < .0001$); and more often the "Accept Option" than the "Reverse Option" (p = .013). In contrast, the older adults chose the "Equilibrate Option" (M = 69.97%, SD = 6.20) and the "Accept Option" (M = 64.37%, SD = 10.06, p = 1) equally, and more often than the "Reverse Option" (M = 15.66%, SD = 8.01, p < .0001).

4.5. Comparisons between the three options in the disadvantageous inequity distributions condition

The analysis revealed a significant main effect of Options [b = 2.2, Wald χ^2 (2) = 216.51, $p < .0001$]. In the Disadvantageous inequity condition, the "Equilibrate Option" (M = 80.14%, SD = 8.18) was more often chosen than the "Reverse Option" (M = 43.25%, SD = 14.22); which was more often chosen than the "Accept Option" (M = 26.62%, SD = 9.40). The analysis also revealed a significant Options × Age interaction [b = −20.38, Wald χ^2 (2) = 16.39, $p < .0001$]. As can be seen in Fig. 4b, the older participants more often chose the "Reverse Option" (M = 56.82%, SD = 13.38) compared to younger participants (M = 29.67%, SD = 13.34, $p < .001$). Moreover, younger participants more often chose the "Equilibrate Option" (M = 86.6%, SD = 7.37) than the "Accept Option" (M = 34.27%, SD = 9.87, $p < .0001$) and the "Reverse Option" (M = 29.67%, SD = 13.34, $p < .0001$). In contrast, the older adults chose the "Equilibrate Option" (M = 74.21%, SD = 9.10) and the "Reverse Option" (M = 56.82%, SD = 13.38, p = .575) equally, and more often compared to the "Accept Option" (M = 18.97%, SD = 8.14, $p < .0001$).

4.6. Payoff Ratio

Based on the different options proposed in the game (i.e., Accept, Reverse and Equilibrate the distributions), we calculated, for each participant separately, the sum of their payoffs and that of the dummy player. According to the options that the participant had chosen, they could obtain a maximum of €1008 and a minimum of €432. Thus, for each participant, we calculated a Payoff Ratio (participant's Payoff sum/dummy player's Payoff sum). The smallest possible ratio was 0.43, suggesting that the participant had maximized the other player's payoffs (i.e., *altruistic orientation)*. A ratio of 1 would suggest that the participant maximized the joint payoffs (i.e., minimized the difference between the two players' payoffs, i.e., *prosocial orientation*). The largest possible ratio of 2.33 would suggest that the participant maximized his/her own payoffs (i.e., *pro-self orientation*). A Mann-Whitney U test was used to examine the median difference between young and older participants, because the data were not distributed normally. The analysis revealed that the Payoff Ratio for older participants (Mdn = 1.34) was significantly higher than the Payoff Ratio for younger participants (Mdn = 1.08), U = 194.5, z = −3.51, $p < .001$, r = −0.46.

4.7. Declared Social Value Orientation

In order to investigate the declared participants' orientation (i.e., pro-self, prosocial or altruistic orientation), we compared the number of selected responses from the Declared Social Value Orientation questionnaire (1 = increase my payoffs; 2 = increase the other player's payoffs; 3 = increase both my payoffs and those of the other player) as a function of Age group. We used the Freeman-Halton extension of Fisher's exact test (FET) to analyse a 3 × 2 contingency table, because more than 20% of the expected cell frequencies were <5. The analysis revealed a significant effect of Age group on the Declared Social Value Orientation (p = .033). Sixty-nine percent of the younger participants and 58.6% of the older adults chose the option to increase both their payoffs and those of the other player, whereas 17.2% of the younger participants and 41.4% of the older participants chose the option to increase their own payoffs. Finally, 13.8% of the young participants and none (0%) of the older participants chose the option to increase the other player's payoffs.

4.8. Relationship between Payoff Ratio and the declared Social Value Orientation

We calculated bivariate Spearman correlations between the Payoff Ratio and the Declared Social Value Orientation and the Payoff Ratio. The results revealed that the Declared Social Value Orientation was significantly correlated with the Payoff Ratio (r = .66, n = 58, p = .0001). Thus, the more the participants declared having chosen to increase their payoffs (pro-self orientation), the greater their actual Payoff Ratio was. Conversely, the more the participants declared having chosen to increase the other player's payoffs (altruistic orientation), the lower their actual Payoff Ratio was. The same analysis was conducted for each Age group separately and revealed that the correlation coefficients were significant for the two groups [older participants (r = .72, n = 29, p < .0001); younger participants (r = 0.48, n = 29, p = .009)].

4.9. Perception bias

In order to evaluate a possible perception bias, we compared the number of selected responses from the Perception bias questionnaire (1 = favourable for me; 2 = favourable for the other player; 3 = identical for me and for the other player) as a function of Age group. As previously, we used the FET exact test to analyse a 3 × 2 contingency table because more than 20% of the expected cell frequencies were <5. The analysis indicated that the number of responses did not significantly differ depending on Age group ($p = .56$). Overall, 79.3% of the young participants and 82.8% of the older participants reported no perception bias, whereas 13.8% of the young participants and 17.2% of the older ones thought that the distributions made by the computer were rather favourable for them. Finally, 6.9% of the young participants and 0% of the older participants thought that the computer's distributions were rather favourable for the other player.

5. Discussion

The present study was designed to investigate disadvantageous and advantageous inequity aversion in younger and older adults in order to differentiate individual profiles with more Prosocial vs. Pro-self vs. Altruistic orientations and to examine age-related effects on these profiles. The study used a game which allowed the participants to maximize or to minimize payoff inequalities. Overall, the main results revealed some important age-related differences related to inequity aversion. Compared to younger adults, older ones more often selected the options which maximized their own payoffs. First, when the alternative "Equilibrate or Reverse" option was presented, older adults reversed the distributions when they more often received disadvantageous inequity distributions than young adults did. Second, when the "Accept or Equilibrate" alternative was presented, older adults less often equalized the distributions when they received advantageous inequity distributions compared to younger participants. Third, when the "Accept or Reverse" alternative was presented, older adults less often reversed the distributions when they received advantageous inequity distributions, compared to disadvantageous ones, while no difference was found in the younger participants. Fourth, in all trials combined of the Disadvantageous inequity distributions condition, the older adults significantly more often selected the *Pro-self option* (i.e., "Reverse") comparatively to the younger ones. Fifth, in all trials combined of the Advantageous inequity distributions condition, the older adults as often selected the *Pro-self option* (i.e., "Accept") as the *Prosocial option* (i.e., "Equilibrate"), while the younger adults significantly more often selected the *Prosocial option* than the other options. All together, these results suggest that the older adults more rarely tolerated receiving less money than the other player (i.e., disadvantageous inequity aversion) than they tolerated receiving more money than the other player (i.e., advantageous inequity aversion). In contrast, the younger adults were more averse to advantageous inequity than older adults and they exhibited a similar level of advantageous and disadvantageous inequity aversion. Using a novel paradigm, the results of our study are more in line with the studies [15,16], that older adults made more strategic and rational economic decisions in order to maximize their payoffs than younger adults did. Indeed, in the studies [15,16], older adults more often accepted unfair offers compared to younger adults in order to maximize their gains. In the present study, the older adults more often reversed the distributions when they received disadvantageous inequity distributions comparatively to the younger adults. Thus, the behaviour of the older adults approximated strategic and rational behaviour predicted by the classical game theory [8,9,40].

Subsequently, we identified a social value orientation profile (i.e., *Prosocial vs. Pro-self vs. Altruistic orientation*) depending on payoff ratios by Age group. The median payoff ratio of younger adults (1.08) was significantly lower than that of older adults (1.34). As a result, younger adults were closer to a ratio of 1, suggesting that they equalized the joint payoffs corresponding more to a *prosocial orientation*, compared to older adults. Although caution must be taken about the strict interpretation of these scores, which is quite far from the theoretical maximum score (2.33 reflecting *Pro-self orientation*), the older adults' median payoff ratio was significantly further from the "*prosocial orientation*" score of 1, compared to the younger adults. Supporting this finding, when being questioned at the end of the experiment, the declared participants' orientation (i.e., P*ro-self, Prosocial or Altruistic orientation*) converged in the same direction. Fewer younger adults than older ones said they wanted to maximize their own payoffs (i.e., *Pro-self orientation*). In addition, some young participants (four) said they wanted to maximize the payoffs of the other player (i.e., *Altruistic orientation*) whereas none of the older participants did. Finally, in this study, nine younger adults and only one older adult actually maximized the payoffs of the other player. In the context of the SVO theory, the results of our study are in line with a recent study [55] conducted among a representative sample of Austrian people. That study used an incentivized SVO Slider Measure to assess prosocial behaviour and found that the latter decreased with Age from 16 to 94 years old [55]. However, our own results and those of Ehlert et al. (2021) [55] contrast with the previous findings made by two studies on SVO using decision games, which were conducted in Japan and the Netherlands and which reported that the prevalence of prosocial orientation increased with age [56,57]. These contradictory results may be explained, at least partly, by methodological differences. The opposite results between age and SVO observed in the study of Van Lange et al. (1997) [57] could probably be explained by the fact that they used a non-incentivized protocol while our study and that of Ehlert et al. (2021) [55] used incentivized games. It is probable the fact that the participants' decisions are really linked to monetary gains could mitigate social desirability by making it costly to appear prosocial. The contradictory results between the study [56], and the present one and that of Ehlert et al. (2021) [55] could potentially be due to cultural differences between Europeans and Japanese regarding social norms and SVO [58,59] but also to their younger sample, as their oldest participants were 59 years old, comparatively to 81 and 94 years in the present study and that of Ehlert et al. (2021) [55], respectively.

Overall, these results revealed that, in our game, older adults more often had a real intention to maximize their gains than younger adults, and therefore behaved in a less prosocial or altruistic manner. Thus, the behaviour of the older adults the approximated strategic and rational behaviour predicted by the classical game theory [8,9,40].

Finally, we checked if the participants in the two Age groups thought the computer sharing choices whether disadvantaged or favoured them, which might have modulated their economic decision-making in favour of selfish or altruistic behaviour. The analysis of Perception bias indicated no difference related to Age group. Overall, both older and younger participants thought that the computer made identical distributions for them and for the other player. Consequently, a perception bias is unlikely to explain this age-related difference in inequity aversion.

All together, all these results support the first hypothesis we proposed: older adults have more *Pro-self orientation* compared to their younger counterparts. Indeed, they significantly more often selected the options which maximized their own monetary payoffs when they received either advantageous or disadvantageous inequity distributions. This result would suggest that older participants are less averse to advantageous inequity (i.e., more *Pro-self orientation*) compared to younger adults (i.e., more *Prosocial orientation*), at least in the context of such economic game. The design advantages of the "Give-and-Take Game" allow a credible interpretation of our results. Firstly, the design of the "Give-and-Take Game" allows to distinguish prosocial behaviours from pro-self behaviours which could be perceived as prosocial behaviours. In the "Give-and-Take Game", the participants can modify the players' gains (i.e., "Equilibrate", "Reverse" or "Accept") without being penalized by the other player, which prevents the participants from using an instrumental fairness to avoid the responder from rejecting his/her offer, aiming at maximizing his/her gain like in the UG. Secondly, the fact that the participants can modify the players' gains (i.e., "Equilibrate", "Reverse" or "Accept") reduces the number of potential motivations associated with rejection unfair offers (i.e., real disadvantageous inequity aversion or jealousy-based motivations) unlike the DG.

Furthermore, it is important to remember that, at the end of the study, the participants were asked to respond to an open question to examine their motivations during the game. Although it was only descriptive, the analysis of the responses showed that most of the older adults, particularly those who wanted to maximize their payoffs, used the following terms: "to win", or "not to lose". It is possible that older adults considered the economic interaction with the other player during this game as a competition requiring a winner and a loser, and were accordingly more motivated to maximize their gain. Conversely, younger adults took into account the social dimension of the game, focusing on a fair monetary distribution. This contrast is striking because both Age groups received exactly the same instructions, as outlined in the Materials and Method section.

Several factors could explain this difference in behaviour between the two Age groups. First, it is possible that older adults inferred a research objective from this study to examine the cognitive abilities of older adults in economic decision-making. This potential inference could have activated negative stereotypes about ageing, such as the idea that older adults are less competent than younger people or that cognitive abilities decrease with age [60,61]. The activation of these age-related stereotypes could have led these participants to demonstrate that they are still performing well in a context of economic decision-making. As a result, the older adults could have adopted self-interested and competitive behaviours with the other player. On the opposite, younger adults might have inferred that the research objective from this study was to assess their prosocial tendencies rather than their cognitive abilities in economic decision-making. This belief about the purpose of the study could have led younger adults to adopt more prosocial behaviour (i.e., to minimize the difference between their payoff and the other player's payoff) and altruistic behaviour (i.e., to maximize the payoff of the other player). On the other hand, it is possible that the older adults detected deception (i.e., that the second player was fictitious). Therefore, they could have decided to maximize their gains as this did not affect the gains of a human player. If so, the older participants' decision would not have been selfish but perfectly rational in comparison to young adults. This final hypothesis seems unlikely as none of the participants in this study reported such belief. Future studies should examine more extensively the influence of age-related stereotypes among older people in the context of economic decision-making and the beliefs that participants may have about the objectives of studies which use economic games [62,63] (e.g., UG, Trust Game, Public Game, Give-and-Take Game).

Second, the participants were told that each member of the pairmate was performing the task separately and that they would be both paid according to the options that they chose. So, each player was supposed to receive a percentage of randomly chosen trials: 1) on the amount that they chose to take in the game and 2) on the amount that their pairmate gave them. The rational and strategic behaviour was thus to maximize their gains without caring about the economic decisions which the other player was going to make (i.e., to equalize the gains of the players or to maximize only their own gains). In the present study, older adults adopted a more rational and strategic behaviour by maximizing their payoffs more often than younger adults did. Are younger adults more inclined to have a more positive view of the behaviour and intentions of their peers than older adults? Did younger adults infer more prosocial behaviour from their partner than older adults did? Would this belief about their partner's behaviour lead them to behave in a prosocial manner? Future studies should also examine these research questions.

Third, several studies highlighted the fact that older adults are more influenced than younger ones by the knowledge of the personal/social features of an individual with whom they are interacting to make a socio-economic decision [64,65] (name, picture, psychological and physical features). A recent study [64] showed that older adults were more generous than younger adults when the recipient was described with positive psychological features and physical characteristics in the DG. Another recent study [65] showed that, compared to younger adults, older ones were less generous with unrelated individuals. Collectively, these findings suggest that older adults might be more selective in showing prosocial behaviours than younger adults. Our study did not give the participants any information about the other player. This could have led older adults to be less prosocial than younger adults. What would have happened in our study if the participants had received social information about the other player (i.e., name, picture, psychological and physical features)? Would older adults have been more generous than their young counterparts or would both age groups have been equally prosocial? In the UG, studies found that older adults less often take the intentions of other players into account but that they are more focused on the others' outcomes, compared to younger adults [65–67]. In the present study, it is possible that the older adults gave less weight to the other player's potential intentions regarding his/her social behaviour (i.e., Prosocial, Pro-self and Altruistic), due to a cognitive decline with age of abilities in theory of mind [68,69].

Some potential limitations to the present study need to be outlined. First, this study used deception, like many studies on UG cited in this article (i.e., participants did not play with a real player). To discern whether the participants believed they were playing with a real person or not, the participants were asked to answer the following question: "Did you believe you were playing this game against a real person?" 100% of the participants answered "YES". Nevertheless, it is possible that a certain number of the participants did not believe that there was another player but that they answered "YES" out of social desirability. We could have potentially avoided this bias with a deception-free protocol (i.e., playing with a real player). However, a large number of studies have found that the characteristics of the other player (e.g., gender, physical attractiveness) influence the participants' generosity [70–74]. In the same way, Eisenbruch et al. (2016) [75] showed that proposers were more generous with responders who seemed most prosocial, most productive and healthier, and with high social status. For all these reasons, the participants did not play with a real human to prevent that social information about the other player (i.e., psychological and physical characteristics) from influencing their decision-making. Secondly, this study compared two extreme-groups (i.e., young adults and older adults) in a cross-sectional design. Adding a group of middle-aged adults could have limited the overestimation of age-related effects using such design [76]. Moreover, future longitudinal studies should be conducted to verify whether these results reflect a true effect of chronological age rather than a cohort effect [77].

One last limitation is that our study did not include a standard UG condition in order to make direct comparisons with previous studies. We encourage future studies to use this new game and to compare their results with our results and others from classical socio-economic games, so as to verify the generalization of our findings.

To conclude, the present study showed that older adults 1) were less averse to advantageous inequity compared to young adults and 2) highlighted a less important *Prosocial orientation* than their younger counterparts in the game. These original results were demonstrated using a novel dilemma game. Further studies are now necessary to examine more precisely the participants' motivations related to their behaviour in such socio-economic game. Moreover, one need now to investigate whether the kind of decisions taken during such a game reflects actual levels of inequity aversion and social orientation or more situational behaviours according to the game itself. For example, it would be important to understand what motivated older adults to focus more on the economic dimension of the game compared to younger adults, who focused more on the social aspect of the game. Could these different behaviours be explained by the fact that older and younger participants inferred differently the goal of the game? Also, manipulating the type of instructions given should allow to better examine and understand the motivation related to young and older adults' behaviour in such dilemma situations.

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Author contribution statement

Agnès Falco: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Anne-Claire Rattat: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Isabelle Paul: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Cédric Albinet: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e17866.

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