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Decoy effects in intertemporal and probabilistic choices the role of time pressure, immediacy, and certainty

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ABSTRACT

A decoy is an irrelevant option that, when added to a binary choice, is not selected but nonetheless alters the subjects' preferences, systematically biasing towards its target. The decoy effect, also known as attraction effect, is considered an anomaly of rational decision-making, albeit its applicability to real-life choices outside of laboratory settings has been challenged. In particular, when decoys have been studied in choices between outcomes occurring at different points in time, i.e. intertemporal choices, or with different probabilities of realizing their utility, i.e. probabilistic choices, results were mixed: sometimes decoys are impactful, sometimes they are not, and they seem to be more effective in biasing towards, respectively, larger-and-later and larger-and-riskier outcomes, rather than towards sooner-and-smaller or sooner-and-safer rewards. We suggest that this puzzling set of results can be clarified by focusing on two important influencing factors: time pressure and immediacy/certainty. Moreover, we argue that decoy effects constitute an excellent testbed to assess similarities and differences between intertemporal choice and risky decision-making, which constitutes another open issue in the study of human choice. Two studies are presented to support these claims. In Study 1 (N = 92), we demonstrate that asymmetrically dominated decoys influence both intertemporal choice and risky decision-making only in the absence of time pressure, since otherwise the comparative process required for the decoy to have an impact cannot occur, consistently with predictions made by connectionist models of decision. In Study 2 (N = 53), we show that, when the smaller option is no longer presented as immediate/certain (but rather as sooner/safer), the impact of decoys becomes symmetrical – that is, they can prompt subjects to become either more future-oriented/risk-prone or more present-oriented/risk-averse. We conclude by discussing the implications of these findings for our understanding of the multifaceted role of time and chance in decision making.

1. Introduction

In everyday life, we often face intertemporal choices, i.e. choices between options that realize their utility at different points in time. Should we invest our well-earned money to buy the fancy car we covet right now, or should we save it for our retirement? Should we gorge on our beloved dessert now, or should we be steadfast in our diet to achieve a trimmer figure in a few months and better health later on in life? Equally ubiquitous are probabilistic choices, i.e. choices between options with different levels of risk associated to them. Is it worth risking our money in an investment plan that may either increase them or lead to losses, or is it better to keep them under the proverbial mattress? Should we play it safe and keep seeing only our old friends, or should we take the risk of getting to know new people, that may either delight or disappoint us? Importantly, many important decisions in life present us with dilemmas that are both intertemporal and probabilistic: when a student contemplates whether to join some friends in a wild weekend of festivities, or stay home and study for an important exam next month, this choice opposes an outcome that is both temporally proximate and almost certain (the enjoyment of the upcoming weekend, if spent partying), against a result that happens to be both delayed and uncertain (obtaining a good grade in the exam next month, after having studied for it). Most investment decisions share the same features: returns on one's investment are always delayed and subject to risk, while the alternative (keeping the money) guarantees immediate liquidity.

Given their ubiquitous nature, intertemporal and probabilistic choices have been extensively studied in economics (Thaler and Johnson, 1990; Weber and Milliman, 1997; Frederick et al., 2002; Read, 2004; Soman et al., 2005; Ariely, 2009), psychology (Kahneman and Tversky, 1982; Rachlin, 2000; Ainslie, 2001; Madden and Bickel, 2010), and neuroscience (Berns et al., 2007; Kalenscher and Pennartz,

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2008; Platt and Huettel, 2008), among other disciplines – both in isolation from and in conjunction with each other (Green and Myerson, 2004; Blackburn and El-Deredy, 2013). On the one hand, intertemporal and probabilistic decision making share some important features: both are subject to discounting process, i.e. the subjective value assigned to an outcome decreases as a function of the delay or the risk associated to it, and the discount functions better suited to explain the actual choice behaviour of participants are the same across both domains (typically, hyperbolic or quasi-hyperbolic functions; Rachlin et al., 1991; Kirby and Marakovic, 1996; Read, 2004); moreover, empirical data reveal a vast variety of systematic anomalies in both intertemporal and probabilistic choices (Tversky and Thaler, 1990; Kahneman et al., 1991; Loewenstein and Prelec, 1992; Rabin and Thaler, 2001; Chapman and Weber, 2006), with respect to the predictions of standard utility maximization theory, thus presenting a challenge to classical views of economic rationality. On the other hand, intertemporal and probabilistic choices also present several striking dissimilarities: identical manipulations (e.g., changing the amount and sign of the rewards under consideration) have different or even opposite effects across these two domains (Green et al., 1994, 1999; Estle et al., 2006; McKerchar and Renda, 2012; Weatherly and Terrell, 2014), whereas intertemporal and probabilistic discount rates often do not correlate within participants, thus suggesting that delayed events are not discounted because of their inherent uncertainty (Reynolds et al., 2004; Ohmura et al., 2005); moreover, these two types of choices have been found to activate different brain areas (Weber and Huettel, 2008; Peters and Büchel, 2009), therefore suggesting the existence of distinct cognitive processes at work in handling intertemporal and probabilistic choices. Thus the growing consensus is that intertemporal and probabilistic decision making, although deeply intertwined in many real-life choices, remain two distinct phenomena, involving at least partially independent cognitive mechanisms (Green and Myerson, 2004).

Importantly, both these domains also figure prominently in the explanation of a garden variety of problematic behaviours: addiction, procrastination, poor investment decisions, dietary problems, lack of compliance with medical treatment, depression – just to mention a few important cases (Madden and Bickel, 2010). The inability to delay gratification and excessive risk-seeking are often indicated as root causes of these behavioural disorders; conversely, most behavioural interventions target either intertemporal or probabilistic attitudes (or both), in order to promote a desirable shift in preferences. Thus studying intertemporal and probabilistic choices is crucial not only to understand our everyday decision making behaviour, but also to gather insight on how to change it, whenever necessary or advisable.

This is where decoy effects come into the picture. A *decoy* is an apparently irrelevant (i.e. non-preferred) option that, if added to a binary context, alters the subjects' preferences between the other two options, strengthening the preference for one of them (the *target* of the decoy) with respect to the alternative (*competitor*). Decoys can be built in a variety of ways (*e.g.* compromise and similarity)[1], but the most frequently used, both in real-life scenarios and experimental studies, are asymmetrically dominated (AD) decoys: options that are clearly inferior on at least one attribute to the target, but not with respect to the competitor (Huber et al., 1982). A well-known real-life example of AD decoy is the set of subscription options *The Economist* website once offered prospective subscribers: they could opt for a web-only access to all their content for $59, a subscription to the print edition for $125, or a combined print and web subscription, *also* for $125. Here the print-only option acts as the decoy, since it is clearly inferior to the target (print plus online access, at the same price), whereas it is not obvious at all whether it is better or not of the cheaper web-only option. In fact, when Ariely (2009) presented a group of people with the original ternary choice, the vast majority (84%) opted for the target, i.e. print plus online; but when the AD decoy was removed and the choice between the other two options (web-only vs. print plus online) was given to participants, only 32% preferred the combined and more expensive deal, thus showing how the presence of the AD decoy had significantly shifted preferences towards the target. This *attraction effect*[2] (AE) of AD decoys implicates the violation of two important axioms of standard utility maximization: the regularity principle, according to which the percentage of preference for an option cannot increase when a third irrelevant option is added to the choice set (Rieskamp et al., 2006), and of the independence of irrelevant alternative (IIA), which states that the rate of preference for the options should not be affected by any irrelevant options added in the choice set (Tversky and Simonson, 1993; Guo and Holyoak, 2002; Chapman and Weber, 2006; but see Frederick et al., 2014, and Yang and Lynn, 2014, for an opposing perspective).

Decoy effects show that, in contrast with the axioms just mentioned, decision-makers evaluate the subjective value of an option by comparing the available alternatives, including those that are irrelevant. Indeed, such comparison process is considered the root cause of some biases (Choplin and Hummel, 2005), since the only reason for which a non-chosen alternative may influence the process is that the preferred option is compared to it and some choice-relevant information is derived from the comparison (Simonson et al., 2013). In particular, *multialternative decision field theory* (MDFT, Roe et al., 2001), based on the decision field theory originally developed by Busemeyer and Townsend (1993), proposes an explanation of why comparing the AD decoy with its target produces an increases of preferences towards the latter. According to MDFT, the decoy compared with the clearly superior alternative produces an adverse emotion ("a negative preference state" according to Roe et al., 2001) for itself and arises a boosting effect for target option, making it more attractive. On the other hand, no effect would involve the competitor, because in that case no obvious ranking is apparent with respect to the AD decoy. Thus an inhibitory process against the competitor (which takes time to arise from the comparative process between the options) would lead to an attractive push for the dominant alternative. Thus this view explains the AE through salience: choices are always made within a context, which plays a key role in making one option attractive, and AD decoys create a choice context that increases the salience of the target option (Bordalo et al., 2012; Connolly et al., 2013). In support to this hypothesis, fMRI studies (Hu and Yu, 2014; Wittmann et al., 2007) have found that the choice for the target option is associated with an activity in the frontal insula, typically correlated with salience detection and a heuristic/intuitive style of decision making. On the contrary, an activity in the anterior cingulate cortex (usually associated with the resolution of cognitive conflicts) and a greater load taken over by the prefrontal cortex (a more reflective system) was observed when the AE did not arise.

Whereas decoy effects have been originally studied as yet another deviation from rational choice behaviour, its applicability to real-life choices outside of laboratory settings has been challenged: Huber et al. (2014) showed some limitations about the elicitation of the decoy effect. In reply to the work of Frederick et al. (2014) and Yang and Lynn (2014), who questioned the validity of the effect, Huber et al. (2014) review some key factors that modulate the attraction effect. Whereas

[1] When there are three options of similar subjective vale and one of the options represents a 'compromise' between the other two alternatives, the compromise effect consists in a bias towards the 'middle' option. Instead, the introduction in a binary context of an alternative that is very similar to a preexisting one, decreases the probability of preferring the directly competing option. In this way similarity-based decoys reduce the preference rate of the near option more than the distant alternative in the attribute space. This bias is known as the similarity effect (Roe et al., 2001).

[2] From now on, to minimize repetition, we will use "decoy effect" and "attraction effect" as synonymous, even though we are fully aware that decoy effects can be induced also without using asymmetrically dominated options, as previously mentioned.

the impact of some aspects are still debated (e.g., the use of non-numerical stimuli), others are well-established: in particular, Huber and collaborators argue that the effect is seen more commonly in case of weak prior preferences rather than with a strong baseline predilection for one of the alternatives. Furthermore, it is crucial that the decision maker understands the dominance relationship between the target and the decoy, and that the experimental sample is not equally split in the preference for one of the two binary alternatives.

Moreover, it appears that the AE is harder to elicit in choices among losses (Malkoc et al., 2013) and in general among options that subjects consider unappealing (Heath and Chateerjee, 1995), since undesirable selection domains may lead subjects to pay more attention to the competitor of the choice. Conversely, and obviously, it is essential that the decoy itself is not particularly desirable for the decision makers

Despite these limitations, here we are interested in evaluating the potential of the decoys as correction mechanisms, in relation to intertemporal and probabilistic choices: insofar as AD decoys can be shown to have a significant and flexible impact on these types of choice, they should also be considered in the context of behavioural interventions, as viable tools to rectify undesirable intertemporal and probabilistic attitudes. Unfortunately, so far only few studies have investigated decoy effects in the intertemporal context: Kowal and Faulkner (2016), using choices opposing an immediate smaller reward to a delayed larger option, demonstrated a decrease in the discount rate when AD decoys have the delayed option as target, but failed to observe any effect of AD decoys targeting the immediate option; in contrast, Gluth et al. (2017) used intertemporal choices where the smaller option was not immediate, just less delayed than the larger one, and in this case AD decoys were effective in shifting preferences towards either target. Similarly, some studies have investigated decoy effects in risky choices: Wedell (1991) pioneered the use of decoys with gambles demonstrating that the dominance structure triggered by the AD decoy can induce a preference reversal effect. More recently, Mohr et al. (2017) observed that, in choices among two lotteries with identical expected utility but different risk level (e.g., 20% of winning 80€ vs. 80% of winning 20€), introducing AD decoy targeting the safer option produced an AE towards it, whereas no decoys targeting the riskier option were used; Cheng et al. (2012) investigated instead the interaction between framing effects and decoy effects, and found that, within a standard opposition between positive (a sure gain of $240 vs. a 25% chance of gaining $1000) and negative (a sure loss of $750 vs. a 75% chance of losing $1000) framing, introducing AD decoys that target the riskier option in the positive frame (e.g., a 15% chance of gaining $1000) and the safer option in the negative frame (e.g., a sure loss of $800) leads to an attenuation of the framing effect on risk attitude. These preliminary findings suggest that AD decoys can be effective in shaping intertemporal and probabilistic preferences, yet they also highlight the need for further research, to better assess the nature, scope, and limitations of their effectiveness.

The two studies presented in this paper are aimed to address specific facets of the influence of AD decoys on intertemporal and probabilistic choice. In Study 1, we assessed the impact of *time pressure* (TP) on decoy effects in intertemporal and probabilistic choices, to gather further evidence in support of MDFT: if AD decoys influence preference via a comparison between decoy and target, the effect should disappear below a certain time threshold, since there is not enough time for the comparative process to produce a preferences shift ; moreover, time pressure has been observed to cancel decoy effects (Pettibone, 2012), and we intended to replicate the same findings in the intertemporal and probabilistic context. Study 2 aimed at pinpointing the role of *immediacy* (having the sooner option available right away) and *certainty* (the complete absence of risk in the safer option) in modulating decoy effects in intertemporal and probabilistic choices: we speculated that the effectiveness of AD decoys targeting the sooner and smaller option, observed by Gluth et al. (2017) but not by Kowal and Faulkner (2016), depends on circumventing immediacy and certainty effects (Keren and Roelofsma, 1995; O'Donoghue and Rabin, 1999; Benhabib et al., 2010; Andreoni and Sprenger, 2012), so that only using sooner options that are not immediate and safer options that are not certain the effects of AD decoys targeting those options become significant. Taken together, the results of these studies shed further light on why, how, and to what extent AD decoys can be effective in shaping intertemporal and probabilistic behaviour.

2. Study 1: time pressure and decoy effects in intertemporal and probabilistic choice

2.1. Materials and methods

2.1.1. Participants

A sample of 113 subjects (F = 90, right-handed = 103) was recruited for the first study through an announcement for a population of Italian native speakers between 18 and 30 years old university students: 65% were students, 6% workers, and 29% carried out both activities. 21 subjects were discarded: 11 of them did not respond to the call, 4 did not pass the attention check and 6 participants did not properly answer the questions (using the keyboard) or they took an excessive time (more than 30 s per question or twice the mean of the SD). These criteria were established before starting data collection.

All 92 remaining subjects successfully completed the first section (no decoy) and then took part in one of two different conditions for the second session: Free condition (N = 46, no time pressure) and Pressure condition (N = 46, 5 s limit to answer each question). Participants were assigned to each condition in order to balance the two groups both in terms of demographics, and with respect to the choice preferences and average response time observed in the first session.

2.1.2. Experimental paradigm

This experiment was run on Qualtrics®, an IT platform designed for online questionnaires. The experiment consisted of two separate sessions a week apart. In the first one participants were informed about the study and asked for their informed consent to participate, as well as providing basic demographic information. Successively, subjects dealt with an attention check and a main task-familiarization session. Subsequently, the actual experiment began. Subjects made 9 intertemporal choices between immediate (SS) and delayed (LL) outcomes. All the items were casually randomized by the IT platform. Successively, subjects had to answer 9 randomized probabilistic questions, between a sure smaller outcome and a risky larger one. Each choice was presented on a separate page and each subject was asked to answer the question using the keyboard (A key for the left option and D key for the right position option): the right-left placement of the options (immediate vs. delayed, sure vs. risky) was also randomized.

After the conclusion of the main task, subjects completed the BIS-11 (Barratt Impulsiveness Scale) of 30 standard non-randomized items (Patton et al., 1995). BIS-11 is a widespread and well-validated self-report instrument to assess the impulsivity construct: here we used it simply as a control measure, to ensure that subjects tested in the two between-subjects conditions, Free vs. Pressure, did not differ in terms of their baseline impulsivity (indeed, no significant difference was observed between the two samples).

The second session was carried out after one week on the same IT platform and participants were assigned to two different conditions, Free vs. Pressure. In the Time Pressure condition participants had 5 s to make a choice. To establish the optimal degree of time pressure to use, we first run a pilot study (N = 13) with the same conditions and questionnaires of the main experiment, in which we examined the binary session questionnaire's response times (Intertemporal: M = 9.13; SD = 2.82. Probabilistic: M = 11.06; SD = 3.02). These baseline data provided us with an estimate of the average response time for both contexts in binary choices. Then these values were compared with those used by Pettibone (2012), to determine an appropriate time pressure: based on these converging evidence, we considered 5 s as adequate to impede full comparison among the alternatives. When we conducted an ex post time response analysis on the binary experimental sessions (Intertemporal: M = 5.672, SD = 2.55; Probabilistic: M = 6.36, SD = 2.53), indeed we noticed that these response times were lower than those in the pilot study, most likely due to the small sample of the latter. However, and crucially, they remained consistently above 5 s, which justifies considering that a suitable limit for the time pressure condition. Even more importantly, average response times for ternary choices in the Free condition were higher than 5 s (Intertemporal: M = 6.63, SD = 4.14; Probabilistic: M = 6.98, SD = 5.15) and, as we shall further discuss in the results section, significantly higher than response times in the Time Pressure condition.

The first task in this second session investigated the presence of endowment effects (i.e. the super-valuation of options that are conceptualized as already owned by the subject) in intertemporal choices: since the results of this task are not relevant for this study and did not interact with the rest of our findings, they will not be reported.

Successively, instructions and a familiarization phase for the decoy task were presented. Participants dealt with 18 intertemporal ternary randomized questions with an AD decoy (3 magnitudes x 3 delays x 2 decoy targets, either SS or LL). Items were developed from those of the first session with the sole addition of the AD decoy. After a new familiarization phase, 18 probabilistic ternary randomized questions with an AD decoy were presented. Once again, items were built on the basis of the first session with the addition of the decoy (3 magnitudes x 3 probabilities x 2 decoy targets, either Sure or Risky). Each choice was presented on a separate page and subjects were asked to answer the question using their keyboard (keys A, S, D), each time randomizing the left-right placement of the three options. The only difference between the two conditions, Free and Pressure, was that participants in the latter condition were forced to make a choice within 5 s for each question. If this did not happen, the answer would be invalidated and the choice excluded from the prize pool that we used to incentivize participants. Below every question in the Pressure condition we presented a countdown indicating the remaining time available.

All the subjects who took part in the experiment received a show-up fee for mere attendance. In addition, subjects were informed that one of their choices would be randomly selected at the end of the experiment and they would receive the outcome chosen in that particular instance. This procedure was intended to ensure that people were incentivized to make all their choices as closely to their actual preferences as possible. Given the frequent need to ensure delivery of the prize at specific future dates (when an intertemporal choice with an option of the delayed prize was randomly selected), participants were paid electronically, through a gift certificate for Amazon.com. Such certificates provide a good approximation of cash, since they can be spent in a high variety of ways and have no expiration date: thus they are often use to incentivize computer-based tasks. Moreover, previous studies (Johnson and Bickel, 2002; Madden et al., 2003, 2004; Lagorio and Madden, 2005) have convincingly shown that, in intertemporal choice tasks, using hypothetical, potentially real, or always real rewards does not significantly impact results.

2.1.3. Materials

The intertemporal binary items were constructed for three magnitudes (small [Immediate $3 to $8 / Delayed $10], medium [Immediate $25 to $65 / Delayed $80], large [Immediate $51 to $129 / Delayed $160]) and three lengths of delay (short (2), average (6), long (18)) framed in calendar unit (weeks): e.g. “Would you prefer to receive $47 today or $80 in 6 weeks?”. The items were constructed assuming an average discount rate of 0.017 (constant *k*), which falls within the range of discount rates commonly observed in the literature: this discount rate was then used to calculate the amount of immediate reward that would make a participant with that discount rate indifferent with respect to the delayed amount presented in that choice, given its value and the associated delay, using Mazur’s hyperbolic function (Mazur, 1987).

Probabilistic binary items were initially built on the basis of the same expected utility (EU) for both the Sure and the Risky option. However, a pilot study showed strong risk aversion in this task, which would make any decoy effect hard to observe. Therefore, with the aim of eliciting risk preferences closer to indifference, we increased the EU for risky rewards by 20% manipulating the risk percentage (e.g. “Would you prefer to have 16$ or the 24% chance of winning 80$?”, instead of “20% chance of winning 80$”). Items were built for three magnitudes (small [Sure $2 to $8 / Risky $10], medium [Sure $16 to $64 / Risky $80] and large [Sure $32 to $128 / Risky $610]) and three percentages of risk (low (24%), even (60%), high (96%)). Obviously the greater the amount of immediate or sure reward was, the greater the delay and the odds against were.

All the 18 items of the first session were reused in the second one, adding an asymmetrically dominated decoy to the original binary choice: half of the times the decoy targeted (i.e. was dominated by) the Immediate / the Sure option, whereas in the other half of the trials the decoy targeted instead the Delayed / Risky option. For instance, the following is an example of a probabilistic choice where the decoy targets the Risky option: “Would you rather have 16$ for sure, a 24% chance of winning 80$, or a 24% chance of winning 72$”. The following instead is an example of an intertemporal choice with a decoy targeting the Immediate option: “Would you rather have 14$ today, 25$ today or 80$ in 18 weeks” (see appendix 1 for the list of items).

2.2. Hypotheses

In running this experimental paradigm, we had the following hypotheses:

1 *Attraction effect*: we expected an increase in the preferences for the Delayed / Risky option when these options were targeted by an AD decoy (TDelayed, TRisky), compared to the condition in which the decoy was absent or targeted the Immediate / Sure option. In the latter case, we predicted decoys would be less effective or ineffective, as already observed in the literature (Kowal and Faulkner, 2016), possibly because overridden by stronger effects, i.e. immediacy effect and certainty effect (Keren and Roelofsma, 1995; Andreoni and Sprenger, 2012).
2 *Time pressure*: according to MDFT we predicted the elicitation of a decoy effect only in the Free condition, since a limited and pressing amount of time would have prevented the cognitive processes required for a systematic comparison among options to impact the subject’s preferences. Importantly, given hypothesis 1 on the specificity of the attraction effect for only decoys targeting the Delayed / Risky option, we expected to detect the impact of time pressure as an interaction effect, rather than as a main effect (Roe et al., 2001).
3 *Magnitude effect*: consistently with the previous literature on the subject (Green and Myerson, 2004), we predicted a dissociation between intertemporal and probabilistic choice – in particular, we expected larger magnitudes to increase the willingness to wait (because of the corresponding increase in the net gain obtained by waiting) but also to decrease the willingness to risk (due to loss aversion, since opting to risk with larger magnitudes entails forsaking a more substantial certain prize). As for ternary choices, we speculated that magnitude would not interfere with decoy effects or with time pressure, since comparisons among different options are neither facilitated nor hindered by manipulating magnitude: this prediction, however, was particularly tentative, since to the best of our knowledge no study has yet investigated the interaction between magnitude effects and decoy effects, or the impact of time pressure in eliciting magnitude effects in intertemporal and probabilistic choices.
4 *Response time*: a longer time should have been recorded in ternary questions compared to binary ones, because of the added cognitive

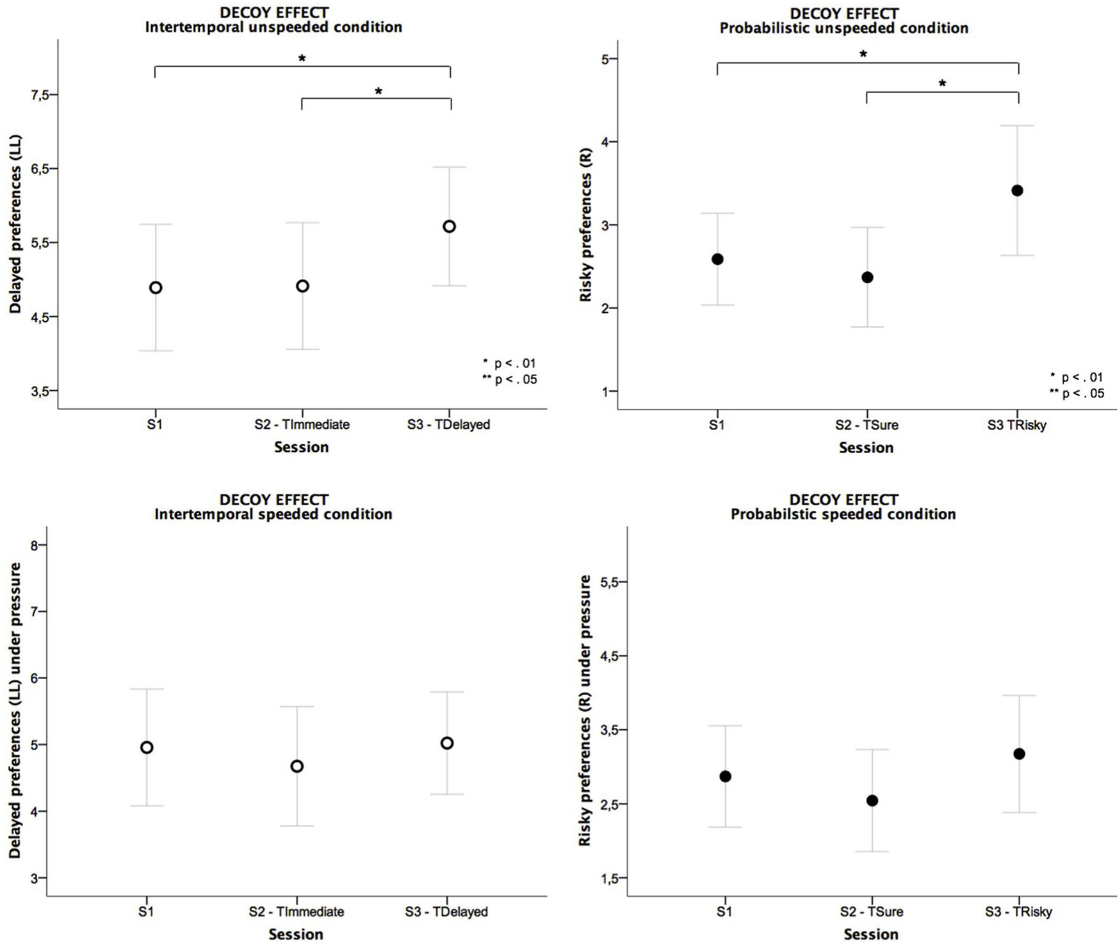

Fig. 1. Decoy effect: number of choices for the delayed (intertemporal - left panel) and risky (probabilistic - right panel) option. The AE was observed both across different sessions one week apart (S1 and S3) and within the same session (S2 and S3) only in the free condition (top panel). No decoy effect has been observed in pressure condition (bottom panel).

load required to process the extra option and run the relevant comparisons.

2.3. Results and discussion

2.3.1. Decoy effects

The main purpose of our study was to verify the elicitation of the AE and the effect of asymmetrically dominated decoy in intertemporal and probabilistic choice contexts. The attraction effect is a classic example of a systematic violation of the regularity principle and of the axiom of the independence of irrelevant alternatives (IIA), since the subjective values assignment in the choice is affected by the addition of a third irrelevant and asymmetrically dominated option (decoy).

For ease of exposition, in what follows we will label Session 1 (S1) the first part of the experiment (binary task), session 2 (S2) the ternary task with the TImmediate/TSure decoy and session 3 (S3) the section with a decoy dominated by the Delayed / Risky outcome. It must be kept in mind that S2 and S3 have been conducted at the same time, a week after S1. We started by looking at the data in the Free condition, i.e. in the absence of any time pressure. The upper row of Fig. 1 shows the percentage of choices for, respectively, the Delayed option in intertemporal choices (on the left) and the Risky option in probabilistic choices (on the right), across S1, S2 and S3 in the Free condition.

A one-way repeated measures ANOVA was conducted to analyse preference rates in intertemporal choices in S1, S2 (TImmediate) and S3 (TDelayed). The results showed a systematic switch in preferences in the presence of a LL-dominated decoy, while no effect occurred in the presence of the decoy with Immediate targets. The effect can be noticed by comparing both the first and second session with the third. The ANOVA highlighted a significant main effect of the session $F(2, 90) = 4.166$, $p = .019$, $\eta p^2 = .085$, showing an influence of the decoy. Indeed, post-hoc analysis showed both a significant difference between S1 (M = 4.891, SD = 2.88) and S3 (M = 5.717, SD = 2.70), p = .036, as well as between S2 (M = 4.913, SD = 2.69) and S3, p = .001, whereas no difference was observed between S1 and S2. This indicates that decoys targeting the Delayed option increased participants' willingness to wait, whereas decoys targeting the Immediate option were ineffective.

We performed the same type of one-way repeated measures ANOVA to analyse the choice rate for probabilistic context in S1, S2 (with TSure) and S3 (with TRisk). Again, results showed a systematic shift of preferences through an increased propensity to choose the Risky option when that was targeted by the decoy, whereas the presence of decoys targeting the Sure option did not have an effect. The ANOVA revealed a significant main effect for the session, $F(2, 90) = 7.584$, $p = .001$, $\eta p^2 = .144$, demonstrating that adding an irrelevant option to the same context of choice affected participants' preferences. Moreover, post-hoc analysis showed both a significant difference between S1 (M = 2.587, SD = 1.86) and S3 (M = 3.413, SD = 2.63), p = .007, and a significant difference between S2 (M = 2.370, SD = 2.015) and S3, p = .001, whereas S1 and S2 once again did not differ significantly.

Taken together, these findings allow us to conclude that regardless of the context, whether it is probabilistic or intertemporal, the presence of an AD decoy without any time pressure causes an attraction effect,

Table 1
Mean values and standard deviations of number of choices for the delayed (intertemporal) and risky (probabilistic) option across different magnitudes, with main effects and post-hoc analyses for the repeated measures ANOVA in each session / condition without time pressure.

Session / condition	M1: Small	M2: Medium	M3: Large	Main effect	M1 vs. M2	M2 vs. M3	M1 vs. M3
S1, Intertemporal	M = 1.043 SD = 1.210	M = 1.891 SD = 1.140	M = 1.957 SD = 1.173	F (2, 90) = 17.288, p < .001, ηp^2 = .278	p < .001	NS	p < .001
S2, Intertemporal	M = 1.000 SD = 1.075	M = 1.957 SD = 1.173	M = 1.957 SD = 1.134	F (2, 90) = 26.708, p < .001, ηp^2 = .372	p < .001	NS	p < .001
S3, Intertemporal	M = 1.348 SD = 1.14	M = 2.109 SD = 1.06	M = 2.261 SD = 1.04	F (2, 90) = 20.362, p < .001, ηp^2 = .312	p < .001	NS	p < .001
S1, Probabilistic	M = 1.109 SD = 0.971	M = 0.783 SD = 0.786	M = 0.696 SD = 0.785	F (2, 90) = 4.239, p = .017, ηp^2 = .086	p = .034	NS	p = .022
S2, Probabilistic	M = 1.174 SD = 0.973	M = 0.717 SD = 0.834	M = 0.478 SD = 0.781	F (2, 90) = 12.767, p < .001, ηp^2 = .221	p = .001	p < .05	p < .001
S3, Probabilistic	M = 1.435 SD = 1.128	M = 1.109 SD = 1.100	M = 0.870 SD = 0.957	F (2, 90) = 6.765, p = .002, ηp^2 = .131	NS	p < .05	0 = .003

i.e. a significant shift in preferences towards the target, although this only happens when the decoys targets Delayed options (in intertemporal choice) or Risky options (in probabilistic choice). It is also worth noting that this effect was observed both across different sessions one week apart (S1 and S3) and within the same session (S2 and S3), providing further evidence of the robustness of the effect. The choices of the participants in all the conditions are summarized in Table 2.

2.3.2. The role of time pressure

In order to verify the role and effect of the time pressure (TP) on the elicitation of the AE and the validity of the connectionist models, we compared the results between subjects who performed the task freely vs. subjects who made it under a time pressure. MDFT suggests that the effect of context on choice results from a series of comparisons between attributes over time. We assumed that if we reduced the time available to make a choice, there would be a significant reduction or outright inhibition of the attraction effect. Importantly, this prediction is consistent with the MDFT explanation of the decoy effect, but not with an interpretation of it is terms of a simple dominance sensitive heuristic. On the heuristic approach, we would expect an attraction effect even under time pressure, since that approach attributes the choice neither to contextual values nor to systematic comparisons, but rather states that the decision is taken immediately as soon as the best feature is identified (Pettibone, 2012).

To contrast these two alternative explanations of the attraction effect, we compared the impact of decoys between the group of participants in the Free condition (G1) and those in the Pressure condition (G2), who faced the same task with a 5 s time pressure. Since both groups completed the first session (S1) under the same condition, i.e. no time pressure, we could not run a single two-ways mixed ANOVA; instead, we performed separate one-way repeated measures ANOVA on both groups. The results for G1 has already been presented and revealed a significant effect of decoys targeting the Delayed or Risky option. In contrast, in G2 the same type of analysis did not reveal any significant differences: thus adding an AD decoy in the presence of a 5 s time pressure failed to systematically shift the subjects' preferences. This lack of effect can be seen in the graphs presented in the lower row of Fig. 1, referred to, respectively, intertemporal choice (on the left) and probabilistic choice (on the right). It is worth noticing that only a small fraction of trials in the Time Pressure condition were terminated before a choice was made: 2.53% of 828 intertemporal choices and 2.65% of 828 probabilistic choices.

Moreover, to make sure that the introduction of time pressure has really affected the decision makers' behavior, a paired-samples *t*-test was conducted to compare response time in the ternary session (S2 + S3) in the free and TP conditions. The results confirmed our methodology since there was a significant difference in the scores for response time both in the intertemporal domain between TP (M = 3.51, SD = 1.11) and free (M = 6.63, SD = 4.14) conditions, t (827) = – 21.656, p = < .001 and in the probabilistic context between TP (M = 3.72, SD = 1.24) and free (M = 6.98, SD = 5.15) conditions, t (827) = – 17.946, p = < .001. The fact that the attraction effect did not emerge under a 5 s time pressure suggests that participants did not have enough time to make the comparisons hypothesized by the MDFT as the cognitive underpinning of the phenomenon. In contrast, these results conflict with attempts of explaining decoy effects as a simple heuristic that manage the preference attribution, since in that case the effect should have been observed also under time pressure.

Overall, this response pattern is in line with MDFT, since it shows that the decision making in intertemporal and probabilistic choices is context-dependent. Adding to the choice set an irrelevant option has significantly altered the previously performed choices, via a systematic comparison between options. Adding a decoy and an "unlimited" time to provide an answer triggers a series of cognitive processes that work by comparing these options. Actually, according to MDFT, decision makers tend to immediately compare options in any environment, but the attraction effect only occurs in the free condition, because the subjective values allocation affected by an inhibitory link and a boosting effect for the target needs time to stabilize. As a result, the value of the outcome is not given *per se*, but it depends on its relation with the other available alternatives, even when these alternatives are clearly inferior to one of the other options. As noted, this constitutes a clear violation of several basic axioms of classical rationality (DUT).

2.3.3. The magnitude effect

To verify our hypothesis on the opposite impact of reward magnitude across intertemporal and probabilistic choices, we performed a one-way repeated measures ANOVA on Magnitude (small, medium, large) for each session (S1, S2, S3) for both intertemporal and probabilistic choices in the absence of time pressure (Free condition). The results of these six ANOVAs are reported in Table 1: whereas a significant main effect of magnitude was always present, the direction of the effect was reversed from one choice context to the other. As shown in Fig. 2, in the absence of time pressure increased magnitude led to more choices for the Delayed option in all intertemporal contexts (open symbols), whereas larger rewards resulted in less Risky choices in the probabilistic domain (black symbols). This is consistent with previous findings on the differences between intertemporal and probabilistic decision making (Green and Myerson, 2004; Weatherly and Terrell, 2014), and it adds to that literature by confirming this dissociation also in ternary choices and in the presence of decoys (S2 and S3).

In fact, further evidence of such dissociation was found by looking at the interaction between time pressure and the magnitude effect across intertemporal and probabilistic choices. When we repeated the same analysis for the Pressure condition, the magnitude effect for intertemporal choices remained unaffected: larger rewards elicited more choices for the Delayed option across all sessions, and the effect was always significant (S1: F (2, 90) = 25.094, p < .001; S2: F (2,

Table 2
"Percentages of choices in the intertemporal and probabilistic ternary context".

				SS/Sure	LL/Risk	Decoy
Experiment 1	**Intertemporal**	Free	DSS	44.93%	54.59%	0.48%
			DLL	34.78%	6353%	1.69%
		Time pressure	DSS	44.93%	51.93%	3.14%
			DLL	38.89%	55.80%	5.31%
	Probabilistic	Free	Dsure	72.46%	26.33%	1.21%
			Drisk	61.84%	37.92%	0.24%
		Time pressure	Dsure	65.94%	28.26%	5.80%
			Drisk	62.80%	35.27%	1.93%
Experiment 2	**Intertemporal**	Free	DSS	58.49%	40.88%	0.63%
			DLL	43.40%	55.76%	0.84%
	Probabilistic	Free	Dsure	77.57%	20.96%	1.47%
			Drisk	63.10%	35.01%	1.89%

90) = 8.964, $p < .001$; S3: $F(2, 90) = 15.424$, $p < .001$). In contrast, the reverse magnitude effect for probabilistic choices survived only in S2 (i.e. with decoys targeting the Sure option; $F(2, 90) = 6.400$, $p = .003$), whereas no significant effect was observed in S1 and S3. This difference in how magnitude interacts with time pressure reveals another asymmetry in the processing of intertemporal and probabilistic choices. It suggests that the impact of magnitude on intertemporal choice is much more automatic and rapid than its impact on probabilistic decisions, so that time pressure does not affect the former yet interferes with the latter.

Finally, in order to test whether a particular reward magnitude makes people more or less sensitive to the decoy effect, we run a two-way repeated measures ANOVA Sessions (S1, S2, S3) X Magnitude (small, medium, large) on choice behaviour in each of the four conditions: Intertemporal Free, Intertemporal Pressure, Probabilistic Free, Probabilistic Pressure. None of these four ANOVA revealed any significant interaction between session and magnitude. These results suggest that the attraction effect due to the presence of AD decoys is not affected by the size of the amounts under consideration.

2.3.4. Response time analysis

Overall, average response times (RT) in all sessions without time pressure were above 5 s, thus confirming that the amount of time given in the Pressure condition was indeed short enough to pressure participants into making their choice sooner than usual. Moreover, a two-way ANOVA Session (S1, S2, S3) X Domain (Intertemporal, Probabilistic) on response times in the Free condition revealed a main effect of Session ($F(2, 826) = 12.480$, $p < .001$) and a main effect of Domain ($F(1, 413) = 17.142$, $p < .001$), as well as a significant interaction ($F(2, 826) = 7.317$, $p = .001$). The effect of domain shows that probabilistic choices in general require more time than intertemporal choices, which could very well depend on the difficulties related to processing odds. The effect of session on response times is more informative: whereas ternary choices with a decoy targeting the Delayed or the Risky option (S3) took longer to process than binary choices without decoy (S1), this was not the case when the decoy was present but targeted the Immediate or the Sure option – in fact, RTs in S2 were marginally lower than RTs in S1, albeit not significantly. Moreover, post-hoc analysis showed that probabilistic choices took longer to process than intertemporal choices in S1 (Intertemporal: $M = 5.672$, $SD = 2.55$; Probabilistic: $M = 6.36$, $SD = 2.53$; $p < .01$) and in S2 (Intertemporal: $M = 5.522$, $SD = 2.59$; Probabilistic: $M = 6.11$, $SD = 3.09$; $p < 0.001$), but not in S3. Considering that S3 was also the only session in which decoys were effective in shifting preferences towards their target, these findings on RTs further corroborate the MDFT hypothesis over alternative heuristic accounts of the attraction effect: even in the absence of time pressure, decoy effects emerge only when participants take the required time to compare the alternatives (S3), and not when the presence of the decoy does not even slow down the decision process (S2) with respect to binary choices (S1).

A further prediction tied to the MDFT hypothesis is that, whenever an attraction effect does occur, its amplitude will be proportional to the time devoted to comparing the choice options: the more time a subject takes to make a decision, the more pronounced the effect of the decoy is expected to be. To verify this, we focused on session 3, the only one in which an attraction effect emerged, and run a correlation between response times and the effect size of the decoy effect, measured as the difference in delayed / risky response between session 3 and session 1. The analysis showed a positive correlation in both contexts (see Fig. 3): the correlation reached full statistical significance at a < 0.05 level only in the intertemporal context ($r = 0.305$, $n = 92$, $p = 0.003$), but the same tendency was apparent also in the probabilistic context ($r = 0.178$, $n = 92$, $p = 0.089$).

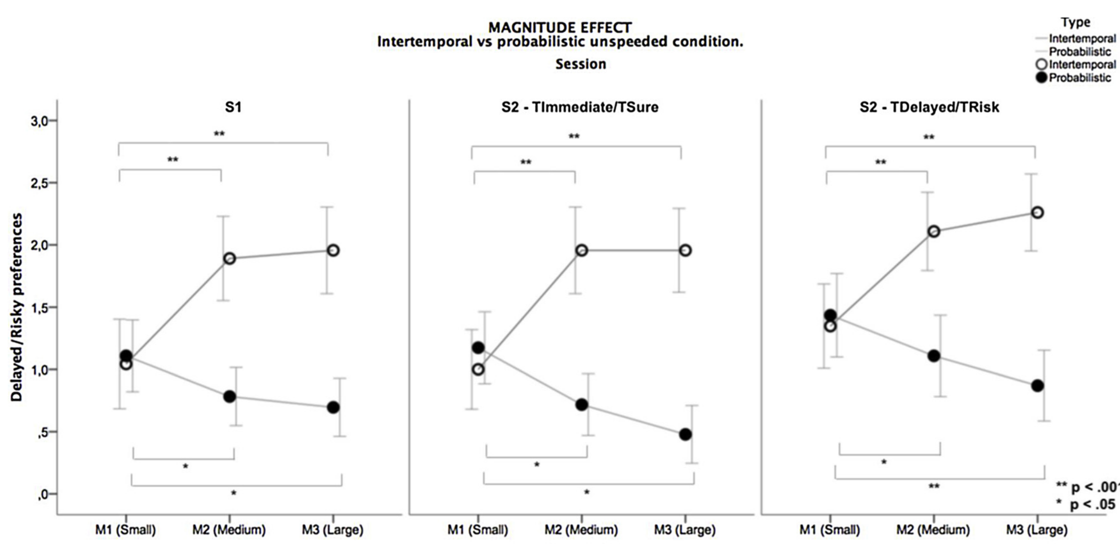

Fig. 2. Magnitude effect: number of choices for the delayed (intertemporal - open symbols) and risky (probabilistic - black symbols) option across different magnitudes in the free condition. The figure shows both a decrease in the delay discounting and an increase in the probabilistic discounting in relation to the increase in the reward magnitude.

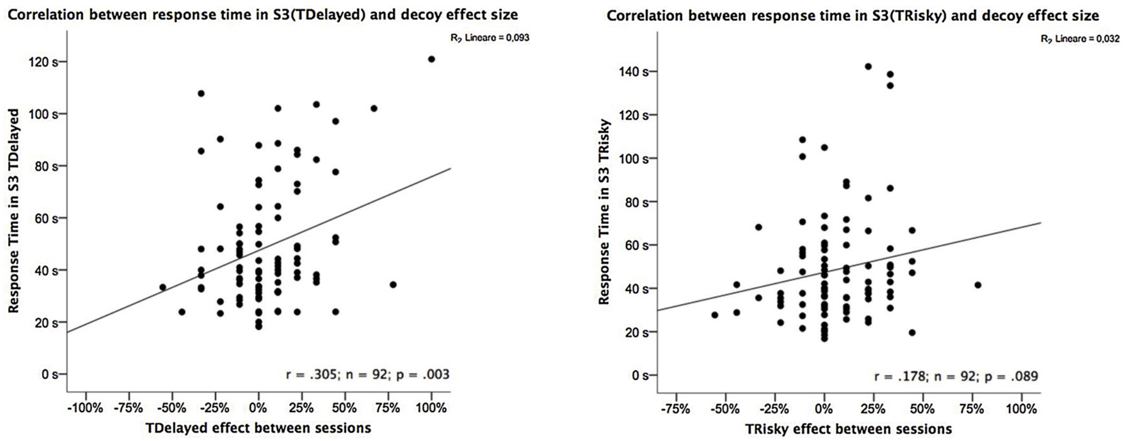

Fig. 3. Correlations between response times in S3 Tdelayed (left panel) / Trisky (right panel) and decoy effect size. In both contexts, longer response time positively correlates with a greater attraction effect.

3. Study 2: decoy effects in intertemporal and probabilistic choice without immediate and certain outcomes

The first experiment revealed an asymmetry in the effectiveness of decoys in intertemporal and probabilistic choice: whereas decoys were effective when targeting the Delayed or the Risky option, no significant effect emerged for decoys targeting the Immediate and the Sure option. We speculated that this asymmetry may be due to the overvaluation of immediate and sure outcomes, as opposed to slightly delayed and relatively safe ones: according to the current literature on the immediacy and the certainty effect (Keren and Roelofsma, 1995; Andreoni and Sprenger, 2012), “right now” and “for sure” are special features of an option, rather than just extreme points on a continuum. Thus it is possible that their impact overshadowed any attraction effect the AD decoys were trying to induce. In order to verify this hypothesis, we run a new version of our main task, replacing the immediate option with a sooner one in intertemporal choices, and the sure reward with a safer one in probabilistic choices.

3.1. Materials and methods

3.1.1. Participants

A new sample of 77 subjects (F = 62, all right-handed) was recruited for the purpose of this study, using the same procedure adopted in the first study: 61% of the participants were students, 5% workers, and 34% carried out both activities. At the end of the first session 24 subjects were discarded: 8 of them did not respond to the call, 4 participants did not properly answer the questions (using the keyboard), and 12 participants were discarded because in the first session they had chosen the same outcome (Sooner, Later, Safer, or Riskier) in all the relevant trials, thus making it impossible for decoys targeting that outcome to have any impact, due to ceiling effects. These exclusion criteria were established before starting data collection to avoid biasing the data sample. All 53 remaining subjects successfully completed the second session.

3.1.2. Experimental paradigm

The basic experimental paradigm was identical to the one adopted in the first study: two within-subjects sessions were run on Qualtrics® one week apart from each other, the first with intertemporal and probabilistic binary choices, the second with ternary choices including an AD decoy. Randomization protocols, choice keys and reward system were identical to study 1. The key differences in this second study were instead the following:

- Immediate options were replaced in all intertemporal choices by Sooner options (i.e. smaller options associated to a shorter delay, with respect to the Later larger reward), and Sure options were replaced in all probabilistic choices by Safer options (i.e. smaller options associated to a lower risk, in comparison with a Riskier larger alternative).
- No time pressure was applied in any condition, thus participants were not divided into two experimental groups before the second session.
- There was no independent manipulation of endowment effects.
- At the end of the first session, participants’ time perception was also assessed using a temporal VAS (Visual Analogue Scale) to estimate perceived perspective duration on three intervals (2, 6, 18 weeks): all participants first provided their estimate for an 18 weeks period, so that it would serve as anchor for the estimates of the other two durations, each presented on a separate page in random order. The whole procedure was based on the protocol developed by Zauberman et al. (2009).

3.1.3. Materials

As mentioned, the key innovation of this study consisted in eliminating safe and immediate outcomes. Instead, the delay associated to the Sooner option in all intertemporal choices was fixed at 1 week, whereas the amounts of the Later options ranged across three magnitudes (small [$20], medium [$80], large [$160]) and could be offered after three delay lengths, expressed in weeks (short [2], average [6], long [18]): e.g., “Would you prefer to receive $52 in 1 week or $80 in 6 weeks?”. The amounts of the Sooner option were calculated by applying Mazur’s formula (Mazur, 1987) and assuming an average discount rate of 0.017, exactly as it had been done in study 1.

Similarly, in probabilistic choices the likelihood of receiving the Safer option was always 90%, whereas the Riskier option raged across three magnitudes (small [$20], medium [$80], large [$160]]) and three percentages of risk (low [20%], even [50%], high [80%]). Since we expected the risk aversion observed in binary choices in the first study to be due to the certainty effect, here for the Safer option we used amount that would guarantee approximately the same EU of the Riskier option: e.g., “Would you prefer a 90% chance to receive $22 or a 20% chance to receive $80?”.

As in the previous study, for each domain (intertemporal and probabilistic,) all the 9 choice items of the first session were reused in the second one: 9 times a Sooner- or Safer-targeting decoy was added, and 9 times we introduced instead a decoy targeting either the Later or Riskier option, for a total of 36 choice items in the second session: “Would you prefer to receive $52 in 1 weeks or $80 in 6 weeks or $76 in 6 weeks?” (see appendix 2 for the list of items).

3.2. Hypotheses

Based on this new experimental paradigm, we had two main hypotheses:

1 *Attraction effect*: in the absence of immediacy and certainty effects, we expected to observe a significant attraction effect also for decoys targeting the Sooner and the Safer option, in addition to those noted when decoys target the Later and the Riskier option. The non-elicitation of the attraction effect in the experiment 1 could thus be attributed to a strong, deep-rooted attraction for the immediate/sure outcome, that would prevent the comparison process hypothesized by the MDFT from occurring.

2 *Magnitude effect*: consistently with previous studies and our own findings in study 1, we expected to observe again a markedly different impact of magnitudes on, respectively, intertemporal choice (larger magnitudes increase willingness to wait) and probabilistic choice (larger magnitudes reduce willingness to risk).

3.3. Results and discussion

3.3.1. Decoy effects in the absence of immediacy and certainty

In comparing preferences expressed in the first and the second session, we will once again label as S1 the first session with binary choices, S2 the second session with ternary choices including a decoy targeting the Sooner or the Safer outcome, and S3 the second session with decoys targeting the Later or the Riskier option. Thus it must be kept in mind that participants completed S2 and S3 on the same day. Choice behaviour across these 3 treatments are summarized in Fig. 4.

As in the first study, we run a one-way repeated measures ANOVA on intertemporal choice preferences across sessions, and this time we found a systematic switch in preferences towards the target option both in the presence of a Later-dominated decoy (as in study 1) and with a Sooner-dominated decoy (contrary to what happened in study 1). The ANOVA highlighted a significant main effect of the session (F (2, 104) = 12.922, $p < .001$, $\eta p^2 = .199$), and post-hoc analyses showed a significant decrease in preferences for Later from S1 ($M = 4.30$, $SD = 2.52$) to S2 ($M = 3.68$, $SD = 2.76$; $p = .034$), indicating that the Sooner-targeting decoys were effective in switching choices towards that option; conversely, there was a significant increase in Later choices from S1 to S3 ($M = 5.02$, $SD = 2.75$; $p = .016$), thus confirming the effectiveness of Later-targeting decoys; as a result, also the difference between S2 and S3 was highly significant ($p < .001$).

The same pattern of results was observed for probabilistic choices: a one-way repeated measures ANOVA across sessions revealed a significant main effect (F (2, 104) = 15.090, $p < .001$, $\eta p^2 = .225$), with less choices for the Riskier option with decoys targeting the Safer one (S1: $M = 2.70$, $SD = 1.67$ vs. S2: $M = 1.89$, $SD = 1.58$; $p < .001$), as opposed to an increase in Riskier choices when that was the option targeted by the decoys (S3: $M = 3.15$, $SD = 217$; $p = .080$), as well as a resulting highly significant difference between S2 and S3 ($p < .001$). In this case the difference in the post-hoc analysis between S1 and S3 was not significant at $p < .05$ level. However, preferences do shift in the direction promoted by the decoy, and indeed the same analysis performed on the percentage of choices for the smaller and safer option (instead of the larger and riskier one) does reveal a significant difference also between S1 and S3. This shows that this lack of significance in the post-hoc comparison is merely due to the interference of choices for the decoy itself in S3, even though they remained limited to a very small percentage (1.90%).

These results confirm our hypothesis on the distorting role of immediacy and certainty in the emergence of decoy effects in, respectively, intertemporal and probabilistic choice. As soon as immediate and sure options are removed from the choice menu, decoys targeting the Sooner or the Safer options are as effective as those targeting the Later and Riskier alternatives, albeit of course in the opposite direction. In terms of cognitive mechanisms, these findings suggest that immediate / sure rewards activate evaluation processes qualitatively different from those evoked by delayed / risky alternatives: in particular, it is possible to surmise that the former are preferred based on simple heuristic processes that do not involve comparisons with other alternative, whereas the latter are valued by contrasting them with all available options. As a result, preferences for immediate / sure options cannot be strengthened by AD decoys, as shown in study 1; yet even including short delays (1 week) or minimal risk (10%) is sufficient to make even Sooner and Safer options susceptible to AD decoys, as demonstrated in study 2.

It is also worth noting that the impact of AD decoys on both intertemporal and probabilistic choices was symmetrical across these two contexts. A two-way repeated measures ANOVA Type (intertemporal, probabilistic) X Session (S1, S2, S3) on choices for the Later / Riskier option confirmed the main effect of decoys (F (2, 104) = 24.220, $p < .001$) and revealed a main effect of type (F (1, 52) = 19.743, $p < .001$), but no interaction among these two variables. This indicates that subjects' reaction to decoys was similar across both choice contexts. The choices of the participants in all the conditions are summarized in Table 2.

3.3.2. Magnitude effects

Results on the magnitude effect confirmed the dissociation already

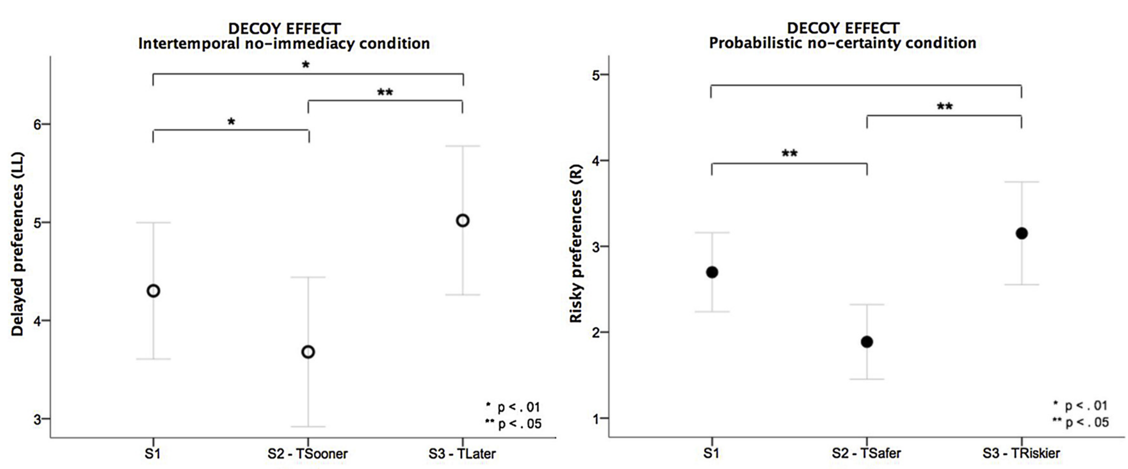

Fig. 4. Decoy effect: number of choices for the delayed (intertemporal - left panel) and risky (probabilistic - right panel) option. The AE was observed both across different sessions one week apart (S1& S3 / S1 & S2) and within the same session (S2 & S3).

observed in the first study: since in this experiment all subjects completed all three sessions, we were able to run a three-way repeated measures ANOVA Session (S1, S2, S3) X Magnitude (small, medium, large) X Type (intertemporal, probabilistic), which confirmed the main effect of both Session ($F(2, 104) = 23.887$, $p < .001$) and Type ($F(1, 52) = 18.318$, $p < .001$), but also revealed no significant interaction between Session and Magnitude, indicating that reward amount impacts similarly on binary (S1) and ternary (S2 and S3) choices, while confirming instead the significant interaction ($F(2, 104) = 74.266$, $p < .001$) between Magnitude and Type. In particular, as already observed in study 1 and in most of the previous literature on magnitude effects, larger rewards increase probabilistic discount rates but instead decrease temporal discount rates.

3.3.3. Time perception

The analysis of VAS results showed a systematic overestimate of the shorter temporal distances. If time perception was linear, one would expect the 6-weeks and 2-weeks estimates to be, respectively, about a third and a ninth of the 18-weeks anchor. To test whether this was the case, we obtained for each subject all the simple linear hypothetical values based on the anchor and we compared them with the real values expressed during the task for the 2 weeks and 6 weeks VAS. A two-way within-subjects ANOVA Type (hypothetical / real) X Duration (2 weeks / 6 weeks) revealed a main effect of type ($F(3, 156) = 139,637$, $p < .001$), with post-hoc analyses showing that real VAS estimates were significantly larger than hypothetical, anchor-based estimates for both 2 weeks (2-real = 18.08, SD = 14.6 vs. 2-hypothetical = 7.98, SD = 1.96; $p < .001$) and 6 weeks durations (6-real = 43.92, SD = 16.96 vs. 6-hypothetical = 23.95, SD = 5.88; $p < .001$). This pattern of results replicates similar overestimates of perceived perspective durations, as observed by Zauberman et al. (2009), and it is consistent with the hypothesis of a logarithmic conversion of objective time intervals into subjectively perceived durations (Takahashi, 2005; Takahashi et al., 2008).

We also observed a significant positive correlation ($N = 53$, $R = 0.305$, $p = .026$) between the VAS scores in the 18 weeks treatment (the anchor) and the percentage of choices for the sooner and smaller option in the binary session. This shows that the longer a time interval is perceived to be overall by a subject, the more that subject is tempted to opt for the immediate outcome, arguably to avoid a delay that looms larger in his/her mind, as opposed to people with lower subjective estimates of the same duration. This result is consistent with previous findings by Kim and Zauberman (2009) on the role of time contraction, alongside diminishing sensitivity to longer time horizons, in shaping intertemporal preferences.

3.4. General discussion

These two studies produced several significant results on how decoy effects and other decision biases systematically affect intertemporal and probabilistic choice. In summary, our main findings allow us to:

- Confirm the presence of systematic decoy effects in both intertemporal and probabilistic choice, under experimental conditions that differ from previous studies on the subject (Kowal and Faulkner, 2016; Gluth et al., 2017; Mohr et al., 2017).
- Provide evidence in favour of one specific hypothesis on the underlying mechanisms responsible for the decoy effect, i.e. multi-alternative decision field theory (MDFT, Roe et al., 2001), against some of its competitors, e.g. simple heuristic decision-making, based on the disappearance of decoy effects under time pressure in Study 1.
- Explain the lack of effectiveness of decoys targeting the sooner / safer option, observed for instance by Kowal and Faulkner (2016), as an artefact of using immediate / sure outcomes: once these outcomes are removed from the choice menu (Study 2), decoys targeting sooner / safer options are as effective as those targeting later / riskier options, consistently with previous findings in studies that avoided such outcomes (Gluth et al., 2017; Mohr et al., 2017).
- Confirm a marked dissociation in how magnitude affects, respectively, intertemporal and probabilistic choice (see also Green et al., 1999; Green and Myerson, 2004; Estle et al., 2006; McKerchar and Renda, 2012; Weatherly and Terrell, 2014), and found no interaction between decoy effects and reward magnitudes: decoys are equally effective for all type of magnitudes tested in these two studies.
- Confirm a systematic distortion in time perception and its impact on intertemporal preferences (Study 2; see also Takahashi, 2005; Takahashi et al., 2008; Kim and Zauberman, 2009; Zauberman et al., 2009).

Taken together, these results highlight the unsuitability of expected utility theory as a descriptive model of intertemporal and probabilistic choice behaviour, which is of course old news; more interestingly, they also provide novel insight on what modulates the effectiveness of decoys in shifting our intertemporal and probabilistic preferences, as well as cementing MDFT as one of the most promising proximal explanation of this phenomenon.

In relation to that, it is worth looking simultaneously at both studies to understand what affects individual sensitivity to decoys. In order to do that, we correlated the propensity to wait or risk in the binary session with the susceptibility to the AD decoys. Interestingly, in both studies we found that the propensity to wait / risk in session 1 positively correlated to the susceptibility to decoys targeting, respectively, the sooner / smaller option, measured as the difference between the percentage of delayed / risky preferences in the TSooner/TSurer condition and the percentage of such preferences in the binary session, whereas it correlated negatively with the susceptibility to decoys targeting the later / riskier options, measured as the difference between the percentage of delayed / risky preferences in the TLater/TRiskier condition and the percentage of such preferences in the binary session; as shown in Fig. 5, all correlations were consistent with this pattern and 6 out of 8 were also statistically significant. This means that the more the subject was set in his/her preference towards one of the options in the initial binary choice, the more effective decoys were in swaying him/her *away* from that preference: in other words, the effectiveness of a decoy appears to be inversely proportional to the initial preference for the option that decoy targets.

The importance of this result is easy to overlook. In the literature, both methodological practice and common sense already suggests to test for decoys by adding them to binary choices that were previously close to indifference between the options, to avoid that either floor or ceiling effects may prevent from observing an attraction effect. In fact, Huber et al. (2014) mention strong prior trade-offs, i.e. a strong initial preference for one of the options in the binary choice, as a general property that might inhibit decoy effects. Our result, however, is more specific than that, and only partially in accordance with it: mere sensitivity to strong prior trade-offs would predict a weakening of the decoy effect for both low and high prior preference towards the target; instead, we found a weakening of the effect when prior preference for the target was high, but instead registered a strengthening of the effect when prior preference for the target was low. Indeed, these results show a progressive increase in decoy sensitivity with the decrease in the initial preference for the target; and this was the case for all types of decoys, both in the intertemporal and in the probabilistic domain. Further studies will be needed to establish whether this is a robust finding, and under what circumstances this correlation is observed. Nonetheless, its potential implications for behavioural interventions remain far-reaching: indeed, it seems to suggest that decoys are not only incisive in changing behaviours, but they may also be particularly effective when the behaviours to be encouraged are initially systematically avoided and/or extremely aversive. Considering that many

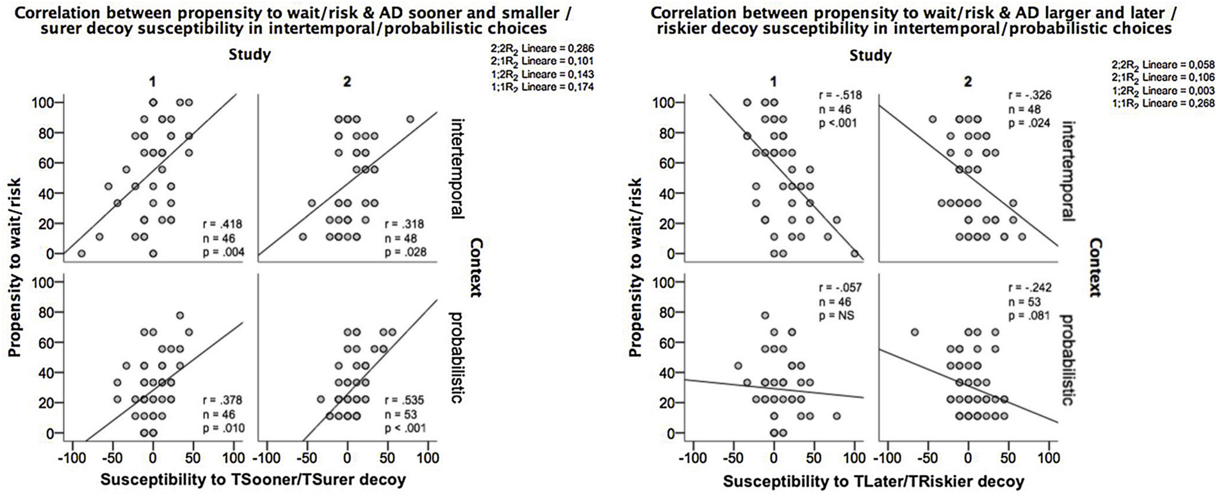

Fig. 5. Correlations between initial preference for later / riskier and susceptibility to decoys targeting the sooner / surer option (left panel) or the later / riskier option (right panel).

problematic behaviours that involve both intertemporal and probabilistic components fall under that description (e.g., gambling, drug consumption, poor investment decisions, health-threatening habits, various impulsivity disorders), decoys may represent a very promising tool for interventions aimed at correcting such behaviours. To paraphrase Archimedes, "give me a preference to sway, and with a decoy I shall move the whole world!".

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