On the Relevance of Irrelevant Strategies*

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Abstract

The experimental literature on individual choice has repeatedly documented how seemingly-irrelevant options systematically shift decision makers' choices. However, little is known about such effects in strategic interactions. We experimentally examine whether adding seemingly-irrelevant strategies, such as a dominated strategy or a duplicate of an existing strategy, affects players' behavior in simultaneous games. In coordination games, we find that adding a dominated strategy increases the likelihood that players choose the strategy which dominates it, and duplicating a strategy increases its choice share; The players' opponents seem to internalize this behavior and best respond to it. In single-equilibrium games, these effects disappear. Consequently, we suggest that irrelevant strategies affect behavior only when they serve a strategic purpose. We show that existing theoretical approaches are unable to accommodate our findings and we suggest an adapted level-k model that is able to do so.

Keywords: Coordination, Dominated Strategy, Salience, Level-k, Asymmetric dominance effect, Experiment.
JEL Codes: C91, D91

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1 Introduction

Suppose that two public transport companies are planning a bus line from one city to another. Both are considering either an express line that drives directly between the cities' central stations or a local-town line that stops in several small towns along the way. Let's further suppose that demand for these lines is such that if they choose different lines, both will make nice profits but the express line will earn more. If they choose the same type of line, they split the demand for that line and both earn less than in the previous case. Table $1(a)$ shows their potential payoffs for each choice.

Now imagine that one of the companies is considering an additional option: A local-village line that stops in a couple of rural villages in between the small towns and is expected to generate the same payoffs as the local-town line regardless of the competing company's strategy. As in the first scenario, each company chooses only one line. This situation is depicted in Table $1(b)$. Would the companies' likelihoods of choosing one type of bus line over the other change due to this strategically duplicated option? Would the likelihood change if the local-village line is expected to generate slightly lower payoffs than the local-town line, regardless of the competing company's strategy (i.e., if it is a strictly dominated strategy)?

In standard solution concepts in game-theory (e.g., Nash equilibrium, correlated equilibrium and rationalizability[1]), such duplicated and dominated strategies are deemed irrelevant, in the sense that the game's outcome does not change whether these strategies are included in the strategy space or not. At the same time, the experimental literature on non-strategic individual behavior has repeatedly documented how seemingly irrelevant options systematically shift decision makers' choices. For example, the presence of an asymmetrically dominated option has been shown to increase the choice probabilities of the option that dominates it, a phenomenon known as the asymmetric dominance effect (Huber et al., 1982). This effect and other *context effects* have been studied almost exclusively in the domain of individual choice. Amaldoss et al. (2008) took the asymmetric dominance effect to the strategic domain and demonstrated that it shows up in coordination games when a dominated strategy is added to one of the two players' strategy set.

In the current study, we extend the scope of the work by Amaldoss et al. (2008) along two dimensions and experimentally examine *two* types of irrelevant strategies in *two* types of strategic contexts. This extension brings about our main contributions: (1) We examine, for the first time, the effect of a duplicated strategy in strategic scenarios (on top of the effect of a dominated strategy), and (2) by analyzing the two strategic contexts jointly, we shed light on the mechanism that underlies the effects of irrelevant strategies in games. Specifically, we show that these effects are not due to an intuitive response, as they appear to be in individual choice contexts. Rather, they show up *only* when they serve a strategic purpose.

[1]These solution concepts were introduced by Nash (1951), Aumann (1974), and Bernheim (1984) and Pearce (1984), respectively.

Table 1: Public Transport Example

Table 1(a)

	Local-Town	Express
Local-Town	40,40	**60,80**
Express	**80,60**	50,50

Table 1(b)

	Local-Town	Express
Local-Town	40,40	**60,80**
Local-Village	40,40	**60,80**
Express	**80,60**	50,50

Notes: In Table 1(a) both companies are considering two lines. In Table 1(b) the company in the row position considers three lines. Equilibria are in bold.

We study eight simultaneous-move one-shot 2x2 matrix-form *base games* to which we add an irrelevant strategy to the row player's strategy set. Thus, for each base game, we construct two 3x2 *extended games*. The added strategy is either dominated by (only) one of the original strategies or a duplicate of one of the original strategies. The dominated strategy yields a lower payoff than another, regardless of the opponents' actions, as in Amaldoss et al. (2008). Clearly, players who maximize their own payoffs should never choose this option. Therefore, their opponents should also ignore it if they maximize their own payoff and believe that others do so as well. The duplicated strategy, as the name suggests, is entirely identical to an existing strategy in terms of both players' payoffs. Unlike a strictly dominated strategy, payoff maximizing players *may* choose this strategy because they should clearly be indifferent between the two identical strategies. However, under standard solution concepts, a duplicated strategy should not be chosen instead of the player's other strategies. Consequently, this addition should not affect their opponents' choices either. Thus, both types of added strategies should not affect the standard game-theoretic analysis of the interaction.[2]

Our base games comprise four *coordination games* and four *single-equilibrium games*. In the former, there are two equilibria, each of which is preferred by a different player. Coordination games are a natural starting point to examine the effect of irrelevant strategies since they present players with an inherent difficulty of coordinating on one of the two equilibria. In these situations, cues–such as the irrelevant strategies we introduce–may serve as an informal guideline for players to follow. However, studying solely these games does not allow to disentangle individual-based effects of irrelevant strategies, i.e., effects that would arise even in individual choice problems, from effects that are due to strategic considerations. Since we are interested in teasing out which of the two underlying mechanisms is in play, we introduce the single-equilibrium games, that are strategically simpler than coordination games (although by no means trivial). As we discuss in Section 6, in

[2]While our main focus in this work is on irrelevant strategies, we also examine the effect of adding a relevant, yet extreme strategy, which we elaborate upon in the next section.

single-equilibrium games irrelevant strategies do not affect players' strategic considerations and hence any evidence for their influence shall be interpreted as an individual-based effect rather than a strategic effect. Thus, examining the single-equilibrium games *alongside* the coordination games brings about our ability to distinguish between the two potential psychological mechanisms.

For each type of game, we examine three effects that the added strategy may have on the games' outcomes. First, the *direct effect*, i.e., the change in behavior of the row players across base games and extended games. Second, the *indirect effect*, i.e., the change in behavior of the column players across base games and extended games. Finally, in the coordination games, we test whether players are more likely to coordinate on one equilibrium over the other in the extended games.

In coordination games, we find that irrelevant strategies affect players' choices. First, in terms of the direct effect, adding an asymmetrically dominated strategy increases the choice likelihood of the strategy that dominates it, and duplicating a strategy increases the likelihood that it will be chosen. Second, these additions seem to be taken into account by the column players: They are more likely to choose the best response to the row player's strategy whose choice frequency increased in the extended games. These findings do not show up in the single-equilibrium games. In fact, we find no evidence that row or column players change their behavior when an irrelevant strategy is added to these games. Thus, irrelevant strategies do not affect players' behavior in every strategic context, suggesting that their influence is not driven only by an intuitive response . In coordination games, players seem to make use of the added strategies as a coordination device: They focus their attention and synchronize their actions on one of the two equilibria, which becomes more prominent due to the asymmetric addition. Indeed, we find higher coordination rates on the equilibrium that is reached when row players choose their dominating/duplicated strategy (and column players best respond to that strategy) compared to the base games.[3]

While the classic approach deems dominated and duplicated strategies as irrelevant, several behavioral models *do* allow for such strategies to affect play. Examples of such models are: Quantal response equilibrium (QRE) (McKelvey and Palfrey, 1995), sampling equilibrium (Osborne and Rubinstein, 1998), level-k thinking(Stahl and Wilson, 1994, 1995), and generalized cognitive hierarchy (GCH) (Chong et al., 2016). Following the analysis of the results in Section 4, in Section 5 we discuss these models in more detail and explore the extent to which they are able to accommodate the patterns in our data. We show that none of them is able to account for the entirety of our findings. Consequently, In Section 6, we sketch a simple adapted level-k model that is able to accommodate *all* of the observed patterns.

[3]Note that irrelevant strategies cannot affect equilibrium selection, according to standard equilibrium refinements, such as perfect equilibrium (Selten, 1988) and proper equilibrium (Myerson, 1978).

2 Related Literature

2.1 Irrelevant Options in Individual Choice

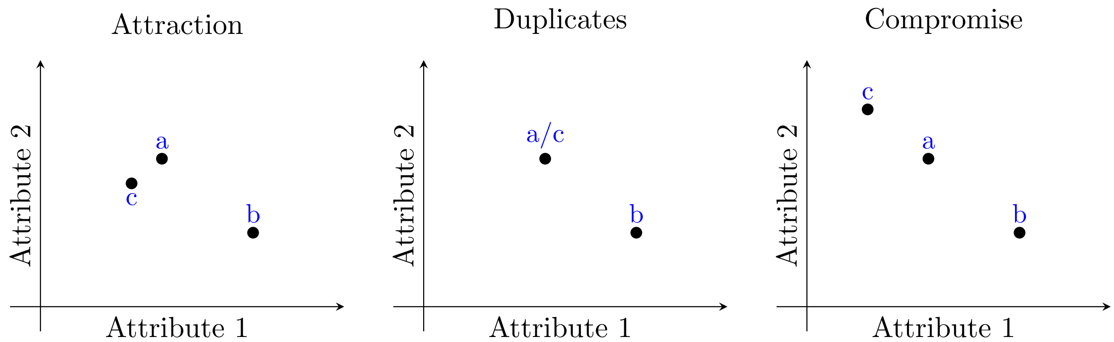
Our addition of an asymmetrically dominated strategy draws upon the individual choice literature on the asymmetric dominance effect, also known as the *attraction effect* (Huber et al., 1982). This effect arises when a decoy option, c, is added to a two-alternative set $\{a, b\}$ (see Figure 1-Attraction). When the decoy is dominated by one alternative (a in Figure 1-Attraction) but not by the other, choices have been found to shift in the direction of the dominating alternative. The experimental evidence for this effect in non-strategic choice problems is large and spans a variety of goods, services and even perceptual decision tasks.[4] Most of the psychological mechanisms that were suggested as explanations for the attraction effect share the idea that the dominating alternative b shines brighter when the decoy alternative is present. This may be due to reason-based approaches, as in Lombardi (2009) and de Clippel and Eliaz (2012), which hinge on ideas raised in Simonson (1989), Tversky and Simonson (1993) and Shafir et al. (1993). It may also stem from dimensional weights (Tversky et al., 1988; Wedell, 1991) or from focusing on different consideration sets (Ok et al., 2015).

The exploration of the effect of a duplicated strategy on players' behavior, which we call the *duplicates effect*, is inspired by the theoretical literature on random choice. It refers to the increase in choice share of an existing option due to an addition of an alternative that is essentially identical to it (See Figure 1-Duplicates). It has been discussed by McFadden et al. (1973) in his famous blue-bus/red-bus example. Similar examples have also been raised by Debreu (1960) and Tversky (1972) to demonstrate a problem that may arise in Luce's random utility model (Luce, 1959), according to which adding a duplicate of an existing option in a choice set would increase the combined choice share of the duo. This problem is known in the literature as the duplicates problem and is discussed by Gul et al. (2014). While theoretically criticized, it is plausible that having one option appear twice highlights its presence, makes it more salient, and thus enhances it in the eyes of the decision maker. It may also lead to naive diversification, i.e., the tendency to spread choices evenly among existing options (as documented, for example, by Benartzi and Thaler, 2001).

There are almost no experimental studies that examined whether a duplicated option does affect individual behavior, or not. In fact, we are aware of only one experiment that addresses the duplicates problem in individual choice conducted 60 years ago by Becker et al. (1963), and in which most of the subjects are not affected by the duplicated option. However, many studies examined the related *similarity effect* in which an option c, which is similar to an existing option, a, but not identical to it, is added to the choice set. In these

[4]See, among many others, Wedell (1991); Ariely and Wallsten (1995); Dhar and Glazer (1996); Doyle et al. (1999); Scarpi (2008); Hedgcock et al. (2009); Trueblood et al. (2013). A more critical view has been raised by Frederick et al. (2014) and Yang and Lynn (2014) while Huber et al. (2014) and Simonson (2014) provide a response.

Fig. 1: Attraction, Duplicates and Compromise Effects in a Two-Attribute-Space



Notes: The attraction and compromise effects refer to the increase in the choice share of a due to the addition of c. The duplicates effect refers to an increase in the choice share of a and c compared to the choice share of a when c is absent.

studies, the choice share of a relative to b drops in the presence of the similar alternative, c. An additional finding, more relevant to our work, is that the combined share of choices of a and c is larger than the share of a when c is not available. When c is very similar to a, adding it to the set may feel like duplicating a. Yet, in the similarity effect literature a and c are never identical, hence, this additional finding can be rationalized with preference maximization.[5]

In addition to our main examination of irrelevant strategies, we also test the effect of adding a relevant, yet extreme strategy, to one player's strategy set. This allows to examine a strategic analogue of the compromise effect, i.e., situations in individual choice contexts in which a *relevant* yet extreme option that is added to the choice set leads decision makers to view one of the original options as a compromise. More specifically, as shown in Figure 1-Compromise, when c is added to a doubleton set $\{a, b\}$, preferences shift in the direction of the midway alternative a.[6] Unlike dominated and duplicated options described above, there may be good reasons to choose the extreme option, even according to standard preference maximization. Nonetheless, as we elaborate upon later, examining it alongside the irrelevant strategies allows us to gain insights into the psychological mechanism underlying the effect of seemingly irrelevant strategies.

[5] For a recent review of the similarity effect, see Wollschlaeger and Diederich (2020).

[6] This effect has also been widely studied in various contexts, such as consumer choice (Simonson and Tversky, 1992), investments (Geyskens et al., 2010) and voting (Herne, 1997). See Lichters et al. (2015) for a review.

2.2 Irrelevant Strategies in Games

Only two experiments examined the effect of adding an asymmetrically dominated strategy in matrix form games. Colman et al. (2007) add an asymmetrically dominated strategy to *both* players' strategy set and find that it increases the choice probability of the dominating strategy. However, given their design, it is impossible to disentangle direct effects of the added strategy from indirect ones. Closer to our work is Amaldoss et al. (2008) who add an asymmetrically dominated strategy only to the row players' strategy set. They examine the effect of this addition in coordination games and find that it increases the row players' choice probabilities of the dominating strategy in one-shot games as well as in repeated interactions with feedback. The column players, however, seem to take the effect of this addition into account only when the game is repeated and feedback is provided. As discussed earlier, we extend the scope of their work by studying a new effect (the duplicates effect) on top of the asymmetric dominance effect, and by examining both effects in coordination games *and* single-equilibrium games. These extensions allow us to draw a more general picture of the effect of irrelevant strategies.

Recently, Galeotti et al. (2021) explore whether the attraction and the compromise effects arise in bargaining games. Their work examines these effects from the point of view of cooperative games. In the experiment, two players need to agree on a payoff allocation, or else they receive nothing, and are allowed to chat freely and make allocation offers until they reach an agreement. In the base games, there are two possible allocations, each one preferred by a different player. In their "dominance extension", there exists another allocation that is Pareto dominated by one of the original allocations but not the other. In their "compromise extension", after adding a third allocation, one of the original allocations becomes second best for both players. Thus, their base game is equivalent to a $2X2$ coordination game, with 2 equilibria, and the extensions are equivalent to $3X3$ coordination games with 3 equilibria. They find that players coordinate on equilibrium in a manner that is consistent with the attraction and compromise effects.[7] Our work complements Galeotti et al. (2021) as they focus on whether the *pair of players* are affected by an added *equilibrium* in the context of *cooperative games*, while we focus on whether each *individual player* is affected by an added irrelevant *strategy* in the context of *non-cooperative games.*

3 Experimental Design

Our experiment consists of eight two-player simultaneous-move base games, of which four are coordination games and four are single-equilibrium games. In the coordination games, each player has to choose between the action that is associated with his preferred equilibrium and the action that is associated with the opponent's preferred equilibrium. In the

[7] Evidence for the compromise effect in similar bargaining environments is also found in Galeotti et al. (2019).

single-equilibrium games, players have to choose between the action that is associated with the equilibrium and the action that is associated with surplus maximization.

For each game, we construct three extended games—a *dominance extension*, a *duplicates extension* and a *compromise extension*. The extended games are constructed by adding a third strategy to the row player's strategy set so that it becomes a 3x2 game. This strategy is either dominated by the top row of the original base game's matrix, identical to it, or more extreme with respect to it.[8] In total, we investigate the players' behavior in 32 games: 8 base games and 3 extended games for each base game. To mitigate subjects' fatigue, 4 unrelated games, which were not presented in matrix-form, were interspersed in between the other games. Table 2 shows one of the coordination base games and one of the single-equilibrium base games alongside their three extensions. All base games, their extensions and experimental details regarding our choice of payoff matrices appear in Appendix A.

We carried out a computerized lab experiment with a between-subject design, i.e, choices of subjects who played the base games were compared to choices of different subjects who played the extended games. For this purpose, subjects were randomly and equally assigned to two groups. In each group, subjects played four base games as row players and the additional four base games as column players. Subjects who played a base game as row players, played all three extensions of that base game as column players, and vice versa. Moreover, a base game and its extension, or two extensions of the same base game, were never played one after the other and were separated by at least two other games (extensions/base games of the other 7 games or one of the 4 unrelated games). To control for order effects, subjects in each group played the games in two opposing orders. In each game, a player was randomly matched with a different anonymous opponent, and for each player, one game was randomly chosen for payment purposes. Subjects received feedback on the games' outcomes only at the end of the experiment.

The experiment was pre-registered on the AEA RCT Registry (Arad et al., 2019). It was held in the Interactive Decision Making Lab of The Coller School of Management at Tel Aviv University. We ran 21 sessions in which 238 subjects participated. Subjects were undergraduate students from various fields of studies who were registered with the lab. Instructions appeared on subjects' screens and were read out loud by the experimenter.[9] Following the instructions, subjects were acquainted with matrix form games in a training session that included 5 matrix-form games and 8 quiz questions with feedback. Each session lasted roughly 45 minutes and subjects' average payoff was 75 ILS (25 ILS show-up fee plus 50 ILS on average earned during the experiment), which were roughly equivalent to 22 USD at the time.

[8] If the strategy a yields a higher payoff for the row player than b when the column player plays one strategy, but yields a lower payoff than b when the column player plays his other strategy, then the row player's added extreme strategy c yields an even higher payoff in the former case and an even lower payoff in the latter. Thus, the strategy a becomes a compromise strategy.

[9] The instructions appear in Appendix B.

Table 2: Payoffs of Base Games 1 (Coordination) and 5 (Single-Equilibrium) and Their Extensions

	Base		Dominance Extension		Duplicates Extension		Compromise Extension	
Game 1 (Coordination)	40,40	**50,80**	40,40	**50,80**	40,40	**50,80**	10,30	**80,30**
	80,50	30,30	35,20	45,20	40,40	**50,80**	40,40	50,80
			80,50	30,30	**80,50**	30,30	**80,50**	30,30
Game 5 (Single-Equilibrium)	40,40	**50,50**	40,40	**50,50**	40,40	**50,50**	20,40	**60,40**
	80,80	30,90	35,30	45,30	40,40	**50,50**	40,40	50,50
			80,80	30,90	80,80	30,90	80,80	30,90

Notes: In every base game the row player's strategies are Top and Bottom while in the extensions, they are Top, Middle and Bottom. The column player has two options – Left or Right. Equilibria are in bold.

4 Results

4.1 Irrelevant Strategies

We define the row player's target strategy as the top strategy in the base games. This is the strategy that dominates the added strategy in the dominance extensions and the duplicated strategy in the duplicate extensions. Thus, the row player's target strategy is Top in the base and dominance extension games, and Top and Middle in the duplicates extension. We define the column player's target strategy as the best-response to the row player's target strategy. The target equilibrium is defined as the outcome that arises when both players choose their target strategy.

We present the results of the direct effect of the added strategy on the row players, followed by the indirect effect on the column players and the effect on the probability of coordination on the target equilibrium.

Direct Effects. Before we proceed to the results, note that out of 476 choices made by the row players in the dominance extensions, there were only 17 choices (3.6%) of the dominated strategy in the coordination games and 13 such choices (2.7%) in the single-equilibrium games. This suggests that subjects were aware that this strategy is dominated by another. Since our main interest lies in the ratio of choices of the two strategies of the base game, the table and the regression analysis below excludes choices of the dominated strategy.

Table 3 shows the percentages of choices of the target strategy by row players in each game. In the coordination games (1-4), the target strategy is chosen more frequently when the irrelevant strategy is present: there is an increase of 3%-11% in the dominance extension and of 10%-25% in the duplicates extension. In single-equilibrium games, the irrelevant strategy has a small and seemingly insignificant effect on the row players. Adding a dominated strategy increases the choice frequency of the target strategy by 0%-9% while

Table 3: Percentages of Target Choices by Row Players

	Coordination				*Single-Equilibrium*			
	1	2	3	4	5	6	7	8
Base Game	59	51	59	56	46	44	54	49
Dominance Extension	62	62	62	66	52	53	54	53
Duplicates Extension	73	76	75	66	49	49	54	51

duplicating a strategy increases its choice frequency by 0%-5%.

Next, we pool together choices for all games of the same type and run logistic regressions in which the dependent variable is a dummy that receives 1 if the target strategy was chosen and 0 otherwise.[10] The main explanatory variable is a dummy that receives 1 when the game is presented in the extended form and 0 for the base form. We control for the game, order in which questions were presented, gender and number of correct answers in the training session.[11] We run three specifications for each effect for each type of game: (*i*) non-clustered errors, (*ii*) clustered errors at the game level, and (*iii*) clustered errors at the game level alongside subject fixed effects.

Tables 4 and 5 report the results of our logistic regressions and provide further evidence for the effect of adding the irrelevant strategy. The coefficient of the extension variable in coordination games (Table 4) is positive and significant at the 5% level in all specifications (odds ratio ranging from 1.32 to 1.56 in the dominance extension, and from 2 to 3 in the duplicates extension). In the single-equilibrium games (Table 5), however, we do not find a consistent effect of the extensions on row players' choices.

Indirect Effects. We now examine whether extending the row player's strategy space has an effect on the column player's behavior. Table 6 shows the percentage of choices of the target strategy by column players. In coordination games, the choice percentage of the target strategy is significantly higher in both dominance and duplicates extension games compared to the base games. This suggestive evidence of an indirect effect is further supported by the regressions that are presented in Table 7.[12] According to the regressions' coefficients, compared to the base game, the column player is between 1.75 to 2.6 times more likely to choose the target strategy when a dominated strategy is added to the row player's strategy set, and 3 to 6 times more likely to choose it when the row player's target strategy is duplicated. In the single-equilibrium games, however, there is no significant effect on the column players' behavior (see the regression results in Table 8).

[10] OLS regressions lead to the same qualitative results.

[11] Running the regressions without the controls does not have any qualitative effects on the results.

[12] We ran the regressions for the column players using the same specifications as the ones used for the row players.

Table 4: Logistic Regression Models: Coordination Games

	Dependent variable: Target Choice					
	Dominance Extension			Duplicates Extension		
	(1)	(2)	(3)	(4)	(5)	(6)
Extension	0.28**	0.28**	0.45**	0.71***	0.71***	1.19***
	(0.13)	(0.12)	(0.20)	(0.14)	(0.12)	(0.22)
Order	-0.05	-0.05		-0.06	-0.06	
	(0.14)	(0.17)		(0.14)	(0.18)	
Gender (male=1)	-0.10	-0.10		0.01	0.01	
	(0.13)	(0.17)		(0.14)	(0.18)	
correct	0.12	0.12		0.07	0.07	
	(0.09)	(0.14)		(0.09)	(0.13)	
$game_2$	-0.15	-0.15	-0.26	-0.11	-0.11	-0.19
	(0.19)	(0.17)	(0.28)	(0.20)	(0.18)	(0.30)
$game_3$	0.01	0.01	0.01	0.04	0.04	0.06
	(0.19)	(0.18)	(0.30)	(0.20)	(0.18)	(0.30)
$game_4$	0.04	0.04	0.06	-0.23	-0.23	0.39
	(0.19)	(0.17)	(0.28)	(0.19)	(0.18)	(0.31)
Constant	-0.49	-0.49	-0.18	-0.16	-0.16	-0.46**
	(0.75)	(0.75)	(0.21)	(0.75)	(1.04)	(0.20)
Observations	935	935	639	952	952	644

Notes: Numbers represent coefficients (β), std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

Table 5: Logistic Regression Models: Single-Equilibrium Games

	Dependent variable: Target Choice					
	Dominance Extension			Duplicates Extension		
	(1)	(2)	(3)	(4)	(5)	(6)
Extension	0.19	0.19*	0.45**	0.10	0.10	0.24
	(0.13)	(0.10)	(0.22)	(0.13)	(0.09)	(0.21)
Order	0.16	0.16		0.12	0.12	
	(0.13)	(0.19)		(0.13)	(0.19)	
Gender (male=1)	0.23*	0.23		0.16	0.16	
	(0.13)	(0.19)		(0.13)	(0.19)	
correct	0.14	0.14		0.06	0.06	
	(0.09)	(0.11)		(0.09)	(0.11)	
$game_6$	-0.04	-0.04	-0.10	-0.05	-0.05	-0.13
	(0.19)	(0.15)	(0.32)	(0.18)	(0.14)	(0.31)
$game_7$	0.19	0.19	0.39	0.25	0.25*	0.56*
	(0.19)	(0.15)	(0.33)	(0.18)	(0.15)	(0.34)
$game_8$	0.08	0.08	0.15	0.10	0.10	0.21
	(0.19)	(0.13)	(0.28)	(0.18)	(0.15)	(0.33)
Constant	-1.54**	-1.54*	0.796***	-0.90	-0.90	0.85***
	(0.76)	(0.90)	(0.20)	(0.73)	(0.93)	(0.21)
Observations	939	939	510	952	952	528

Notes: Numbers represent coefficients (β), std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

Table 6: Percentages of Target Choices by Column Players

	Coordination				*Single-Equilibrium*			
	1	2	3	4	5	6	7	8
Base Game	41	48	48	46	53	55	46	50
Dominance Extension	50	61	61	65	46	58	49	55
Duplicates Extension	68	76	62	78	63	57	46	51

Table 7: Logistic Regression Models: Column Players' Response in Coordination Games

	Dependent variable: Target Choice					
	Dominance Extension			Duplicates Extension		
	(1)	(2)	(3)	(4)	(5)	(6)
Extension	0.56***	0.56**	0.981**	1.07***	1.07***	1.78***
	(0.13)	(0.11)	(0.20)	(0.14)	(0.12)	(0.23)
Order	0.08	0.08		0.06	0.06	
	(0.13)	(0.17)		(0.14)	(0.17)	
Gender (male=1)	0.19	0.19		0.06	0.06	
	(0.13)	(0.17)		(0.14)	(0.17)	
correct	-0.03	-0.03		0.01	0.01	
	(0.09)	(0.09)		(0.09)	(0.08)	
$game_2$	0.36*	0.36**	0.68**	0.32	0.32*	0.49
	(0.19)	(0.16)	(0.28)	(0.19)	(0.17)	(0.30)
$game_3$	0.36*	0.36**	0.62**	0.02	0.02	0.03
	(0.19)	(0.17)	(0.30)	(0.19)	(0.18)	(0.30)
$game_4$	0.40**	0.40**	0.74***	0.34*	0.34*	0.52*
	(0.19)	(0.17)	(0.28)	(0.19)	(0.17)	(0.30)
Constant	-0.44	-0.44	0.13	-0.54	-0.54	-2.58***
	(0.74)	(0.76)	(0.20)	(0.76)	(0.70)	(0.30)
Observations	952	952	680	952	952	704

Notes: Numbers represent coefficients (β), std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

Table 8: Logistic Regression Models: Column Players' Response in Single-Equilibrium Games

	Dependent variable: Target Choice					
	Dominance Extension			Duplicates Extension		
	(1)	(2)	(3)	(4)	(5)	(6)
Extension	0.05	0.05	0.09	0.15	0.15	0.33
	(0.13)	(0.10)	(0.23)	(0.13)	(0.10)	(0.22)
Order	-0.39***	-0.39**		-0.37***	-0.37*	
	(0.13)	(0.19)		(0.13)	(0.20)	
Gender (male=1)	0.16	0.16		0.16	0.16	
	(0.13)	(0.19)		(0.13)	(0.20)	
correct	-0.34***	-0.34**		-0.28***	-0.28**	
	(0.10)	(0.15)		(0.10)	(0.13)	
$game_6$	0.28	0.28*	0.60*	-0.09	-0.09	-0.17
	(0.19)	(0.14)	(0.31)	(0.19)	(0.13)	(0.29)
$game_7$	-0.09	-0.09	-0.19	-0.48***	-0.48***	-1.07***
	(0.19)	(0.14)	(0.31)	(0.19)	(0.15)	(0.34)
$game_8$	0.12	0.12	0.26	-0.31*	-0.31*	-0.67*
	(0.19)	(0.13)	(0.29)	(0.19)	(0.16)	(0.36)
Constant	3.09***	3.09***	0.91***	2.85***	2.85***	1.46***
	(0.82)	(1.19)	(0.19)	(0.80)	(1.07)	(0.24)
Observations	952	952	524	952	952	504

Notes: Numbers represent coefficients (β), std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

Coordination Rates on Target Equilibrium. We now focus on the coordination games and ask whether the introduction of the additional strategy increases coordination rates on the target equilibrium. Many studies have identified factors that facilitate coordination in two-player games (see Camerer, 2011 for a review). These include behavioral mechanisms, such as order of play (Amershi et al., 1992; Rapoport, 1997) and framing (Hargreaves Heap et al., 2014), as well as more rational factors such as the presence of an outside-option (Cooper et al., 1994), the game's symmetry (van Elten and Penczynski, 2020), recommendations (Van Huyck et al., 1992; Brandts and MacLeod, 1995) and communication (Cooper et al., 1994). We contribute to this literature by examining whether adding a dominated or duplicated strategy facilitates coordination.

Table 9 shows the percentages with which each of the coordination game's outcomes was reached. Recall that each player was randomly matched with another player in each game. The percentages in the table are calculated according to the outcome of play of this random matching.[13] Equilibria in each game appear in bold and the target equilibrium is marked with an asterisk.

The dominance and duplicates extensions have higher coordination rates on the target

[13] As we are interested in actual rates that the target equilibrium was reached, in this section we do not exclude choices of the dominated strategy. However, outcomes that involve these actions do not appear in Table 9.

Table 9: Coordination Rates

	Base		Dominance		Duplicate	
Game 1	33	**26***	33	**28***	26	**47***
	26	15	**17**	21	**6**	21
Game 2	**24***	28	**37***	24	**55***	21
	24	**24**	24	**13**	21	**3**
Game 3	**30***	29	**36***	24	**50***	25
	18	**24**	24	**13**	13	**13**
Game 4	33	**24***	21	**40***	12	**54***
	21	23	**12**	19	**10**	24

Notes. Outcome distribution per coordination base game and corresponding extension. Numbers present percentages. Equilibria are in bold. Each game was played by 119 row players and 119 column players. The target equilibrium is marked with *.

equilibrium than the base games in all four games. The effect is relatively large in the duplicates extensions, in which the probability of reaching the target equilibrium is 47% – 55% compared to 24%-30% in the base games. The coordination increase in the dominance extensions is in the range of 2% to 16%.

We also run logistic regressions to examine the increase in the likelihood of reaching the target equilibrium for each extension, aggregated over the four coordination games (Table 10) while controlling for the games themselves. The dependent variable is a dummy that receives 1 if the target equilibrium was reached and 0 otherwise, and the main explanatory variable is the dummy for the relevant extension. For each extension, we run two specifications: one with no fixed effects (1 and 3 in Table 10) and one with subject fixed effects (2 and 4 in Table 10). The regressions show a significant positive increase in the likelihood of reaching the target equilibrium in the dominance or duplicates extensions.

4.2 Relevant Strategy

The added strategy in the compromise extensions was chosen in 13.7% of the cases in the coordination games and 17.6% in the single-equilibrium games which is evidence of the fact that it is indeed perceived as a relevant strategy. Table 11 reports the relative choice share of the compromise strategy (Up in the base game and Middle in the extension) compared to the competing strategy (Bottom), excluding choices of the added strategy. There seem to be no significant differences in choice shares of the compromise strategy between base games and extensions. The logistic regressions in Tables 12 and 13 further support this impression as the coefficients on the extension dummy variables are not significant for any type of game.

Notice that in the compromise extensions, the added strategy is an equilibrium strategy

Table 10: Logistic Regression Models: Target Equilibrium

	Dependent variable: Target Equilibrium			
	Dominance Extension		Duplicates Extension	
	(1)	(2)	(3)	(4)
Extension	0.45***	0.64***	1.11***	1.62***
	(0.14)	(0.17)	(0.14)	(0.18)
$game_2$	0.167	0.347	0.12	0.10
	(0.20)	(0.25)	(0.20)	(0.24)
$game_3$	0.30	0.46*	0.15	0.15
	(0.20)	(0.24)	(0.20)	(0.24)
$game_4$	0.246	0.362	0.10	0.11
	(0.20)	(0.25)	(0.20)	(0.24)
Constant	-1.237***	-0.651***	-1.15***	-1.36***
	(0.167)	(1.03)	(0.16)	(1.16)
Observations	952	851	952	920

Notes: Numbers represent coefficients (β), Std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

in the extended game while the compromise strategy is not. Thus, more choices of the compromise strategy by the row players in the extensions could only be explained by an individual-based compromise effect. As we elaborate upon in Subsection 4.3, we suggest that our finding of no compromise effect is evidence for the fact that individual-based biases do not automatically translate into strategic environments.

As for indirect effects, notice that in these extensions the column players' best response to the row players' compromise strategy is the same as their best response to the added strategy. Therefore, column players' choices in these extensions do not allow to disentangle whether they expect to play against a behavioral action of a row player, i.e., the compromise strategy, or against a row player who is trying to reach the game's new equilibrium. Thus, we do not examine their behavior in this extension.

Table 11: Percentages of Choices of the Compromise Strategy by Row Players

	Coordination				*Single-Equilibrium*			
	1	2	3	4	5	6	7	8
Base Game	59	51	59	56	46	44	54	49
Compromise Extension	53	51	63	54	39	36	48	47

Table 12: Logistic Regression Models: Compromise Effect in Coordination Games

	Dependent variable:		
	Choice of Compromise Strategy		
	(1)	(2)	(3)
Compromise Extension	-0.04	-0.04	-0.15
	(0.14)	(0.12)	(0.22)
Order	-0.02	-0.02	
	(0.14)	(0.18)	
Gender (male=1)	-0.27**	-0.27	
	(0.14)	(0.18)	
correct	0.05	0.05	
	(0.09)	(0.11)	
$game_2$	-0.18	-0.18	-0.38
	(0.19)	(0.17)	(0.32)
$game_3$	0.21	0.21	0.33
	(0.19)	(0.18)	(0.32)
$game_4$	-0.03	-0.03	-0.07
	(0.19)	(0.16)	(0.30)
Constant	0.01	0.01	1.2***
	(0.76)	(0.89)	(0.23)
Observations	887	887	562

Notes: Numbers represent coefficients (β), Std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

Table 13: Logistic Regression Models: Compromise Effect in Single-Equilibrium Games

	Dependent variable:		
	Choice of Compromise Strategy		
	(1)	(2)	(3)
Compromise Extension	-0.22	-0.22**	-0.15
	(0.14)	(0.11)	(0.23)
Order	0.12	0.12	
	(0.14)	(0.20)	
Gender (male=1)	0.13	0.13	
	(0.14)	(0.20)	
correct	0.03	0.03	
	(0.09)	(0.10)	
$game_6$	-0.12	-0.12	-0.35
	(0.20)	(0.17)	(0.35)
$game_7$	0.33*	0.33**	0.64*
	(0.19)	(0.17)	(0.36)
$game_8$	0.21	0.21	0.27
	(0.19)	(0.15)	(0.31)
Constant	-0.64	-0.64	1.06***
	(0.77)	(0.87)	(0.24)
Observations	868	868	469

Notes: Numbers represent coefficients (β), Std. errors in parentheses.
*p<0.1; **p<0.05; ***p<0.01.

4.3 Discussion

In coordination games, we find that adding an irrelevant strategy in the form of a dominated/duplicated action assists in stirring the row players' actions in the direction of one equilibrium over another. At the same time, the addition of these strategies has no effect on the row players' actions in single-equilibrium games, where the decision is whether to play an equilibrium strategy or a surplus maximizing strategy. The different patterns across types of games indicate that our row players' behavior is not a manifestation of individual-based biases, i.e., it is not due to an automatic reaction to the added strategy that arises without consideration of the strategic situation at hand. Rather, it seems that the irrelevant added strategy impacts row players' actions through their desire for cues to facilitate coordination, that is, it serves a strategic purpose.

The column players choose to follow their target strategy, which is consistent with best responding to the target strategy of the row player, more often in the extended coordination games than in the base games. Moreover, just like the row players, they do not exhibit this pattern in the single-equilibrium games. Thus, it seems that the column players utilize the added strategy as a means for coordination, similarly to the row players.

Putting these behavioral patterns together, it seems that both row and column players may be thinking about the irrelevant strategy as a public coordination device. As our analysis confirms, these patterns of row and column players lead to higher coordination rates on the target equilibrium in the presence of the irrelevant strategy.

The addition of the extreme relevant strategy, does not seem to have any effect on the row players in any type of game. Notice that in this case the added strategy is part of a new equilibrium of the extended game. Thus, the potential for a behavioral reaction that corresponds to the compromise effect, i.e., a tendency to choose the middle strategy, is offset by strategic considerations of reaching an equilibrium. Given the above support for strong strategic considerations of our subjects, it is not surprising that when the added strategy is a legitimate choice for a strategic row player, its "behavioral role" in highlighting the middle action is attenuated.

5 Related Theoretical Approaches

We discuss four behavioral models that allow seemingly irrelevant strategies to affect behavior. Following a brief outline of each model's main components, we examine to what extent it is able to accommodate the choice patterns that show up in our experiment. That is, we check whether it predicts an increase in target choices by both players when an irrelevant strategy is added to coordination games but no effect of such an addition in single-equilibrium games.

Quantal Response Equilibrium (QRE) (McKelvey and Palfrey, 1995). This concept is a generalization of Nash Equilibrium that allows for errors in players' optimizations.

Given an error structure, a player's probability of choosing a given action is equal to the probability that the action is optimal given his belief regarding his opponents' strategies. In a QRE, the players' beliefs are correct.

In most of the theory's applications, players' errors are assumed to be i.i.d across strategies, and every error is drawn from an extreme value distribution. This specification leads to the logistic quantal response function in which the probability of player i choosing strategy j is given by

$$p_{ij} = \frac{e^{\lambda \bar{u}_{ij}(p_{-i})}}{\sum_k e^{\lambda \bar{u}_{ik}(p_{-i})}}$$

where $\bar{u}_{ij}(p_{-i})$ is the utility for player i when he chooses action j given that other players are playing according to the probability distribution p_{-i}.

The QRE model with the above response function accommodates some of our findings. For example, it predicts that in coordination games a strategy will be chosen more often when it is duplicated compared to when it is not. However, consider a duplicated strategy in a single-equilibrium game. Suppose that the column player in the duplicates extension maintains similar choice probabilities between Left and Right as in the base game (which is what we find in the data). Given this behavior, the model predicts that the row player would choose the target strategy more often in the duplicates extension (i.e., Up or Middle) than in the base game (Up), in contrast to our findings. In addition, the logistic response function assigns a non-negligible probability to choosing the added dominated strategy in the attraction extensions (especially when the dominated strategy yields payoffs which are only slightly lower than those of the dominating strategy as in our experiment). This feature of the model is at odds with our findings, as row players almost never chose the added dominated strategies.

Sampling Equilibrium (Osborne and Rubinstein, 1998). According to this concept, a player behaves as if he sampled each of his actions once, observed the outcome of playing the sampled action against a random player from the population, and chose the strategy which was associated with the highest payoff. In a sampling equilibrium, the probability with which a player chooses an action is the probability with which that action achieves the highest payoff.

This procedure allows for multiple equilbria in our base coordination games and in their duplicates extensions. For example, the row player choosing Up with probability p and the column player playing right with probability p is a sampling equilibrium of the coordination base games, for any $p \in [0, 1]$. In their duplicates extension, we get a similar set of equilibria: Row players chooses Up and Middle, each with probability $p/2$, and the column player chooses right with probability p. This multiplicity of equilibria may explain the pattern of our comparative statics, but it may also explain any other pattern. Thus, this procedure is unable to generate precise predictions in our set up. At a more general level, this equilibrium notion is more suitable to dynamic situations in which one samples his own strategies in order to learn about the best course of action (as in trying to find the fastest route to the workplace by trying a different one every day).

Level-k Thinking (Stahl and Wilson, 1994, 1995; Nagel, 1995). The level-k model assumes that the population of players consists of a number of types that differ in their depth of reasoning. A level-0 player is non-strategic and is assumed to choose each of the strategies with equal probability. For any $k \geq 1$, a level-k type best-responds to the belief that he faces a player of level $k-1$. The estimated distribution of types in experimental games is qualitatively stable across contexts and suggests that most of the players are either level-1 or level-2 types.

Applying this model to the games in our experiment, we first notice that level-0 row players choose each of their available strategies with probability 0.5 in the base games and 0.33 in their extensions. Level-0 column players choose each of their strategies with probability 0.5 in all games.

The behavior of level-0 row players seems to fit our findings in coordination games of a larger share of choices of the target strategy in the duplicates extension compared to the base games. However, level-1 column players best respond to level-0 row players by choosing their target strategy both in the base games and in their duplicates extension. In fact, none of the other types' behavior (column or row players) differs across base games and their extensions. Therefore, the model cannot explain the behavioral pattern of column players in the duplicates extensions of coordination base games.

The model cannot account for the differences in behavior between the base coordination games and their dominance extensions either. Based on the specified behavior of level-0, and since the added dominated strategy has a fixed payoff for the column player, both column players and row players of level-1 choose the same strategy in the base games and in their dominance extensions. It readily follows that level-2 players and higher-level types, row or column, do not change their behavior across base games and their extensions. Thus, the model predicts that the only difference in behavior between the base games and the dominance extensions is due to the level-0 row players. This implies that the target strategy's choice probability *does not* increase in the dominance extensions of coordination games. It also predicts that the dominated strategy is chosen with a probability of 0.33 while we find that it is barely chosen.

Generalized Cognitive Hierarchy (GCH) (Chong et al., 2016). This model is a generalization of cognitive hierarchy (CH) theory (Camerer et al., 2004). In CH, level-k players , for $k > 1$, best respond not only to level-$(k-1)$, as in the standard level-k model, but to lower levels as well, according to their actual proportion in the population; level-0 players choose each action with equal probability. GCH generalizes this model in two respects. First, it allows players to use "stereotypes," i.e., assign more weight to frequently occurring lower level types. Second, it modifies the behavior of level-0 players: While in the standard level-k model, they choose each available strategy with equal probability, in GCH they are more likely to choose from a set of strategies that never yield the minimal payoff given any strategy of the opponent (which is dubbed the "never worst set" of strategies). If this set is empty, then they choose randomly with equal probabilities as in CH and the standard level-k model.

Due to the modification, level-0 players are more likely to choose the target in the dominance extensions of coordination games than in the corresponding base games. They also increase their choice probability of the duplicated strategy in coordination games (since there are no strategies that are never worst, each strategy is played with equal probability). Note that the model equally predicts an increased choice probability of the row players' target strategies in the single-equilibrium games. Thus, if there is a significant proportion of level-0 types in our sample, they would generate predictions that are in line with our findings in coordination games but at odds with those that show up in single-equilibrium games.

We now consider the model's predictions if there is only a very small proportion of level-0 players in the population. In this case, the model would predict almost no effect by any player in single-equilibrium games (due to the dominant strategy of the column player, the only effect that may arise in these games is that of level-0 players). However, the model would also predict virtually no effect between coordination base games and their extensions. The reason is that, as in the standard level-k model, a level-1 column player best responds to level-0 by choosing the target strategy in both base games and their extensions. A level-2 (or level-3) column player's choice depends on the distribution of level-1 and level-0 players. Roughly speaking, for distributions that assign a relatively large weight to level-1 players compared to level-0 players, his best response is not the target in both the base game and its extensions.[14].

6 An Adapted Level-k Model

In this section we slightly tweak the standard level-k model in a manner that allows to capture our findings in their entirety.

First, we follow a strand of the level-k literature that assumes a level-0 type who is attracted to salient strategies (e.g., Crawford and Iriberri, 2007; Arad, 2012; Arad and Rubinstein, 2012; Hargreaves Heap et al., 2014; Alaoui and Penta, 2016). We assume that a level-0 row player is attracted to a strategy when it is highlighted by the additional strategy, in a manner that makes the former salient. In other words, our level-0 type will be attracted to the target. When no such highlighting takes place, this level-0 row player

[14]Stereotype bias can only shift weights even further away from level-0 players when their proportion is very small.

chooses uniformly from his set of available actions as in the standard level-k model.[15]

The second adjustment that we make is related to risk aversion. In most applications of level-k theory, players are assumed to be risk neutral. However, there is ample evidence that individuals may be risk averse even when facing small or moderate stakes as in our experiment. We follow this evidence and assume that players have various attitudes toward risk and that some of them are moderately risk averse.[16]

As we show below, this adapted level-k model predicts that: (a) In single-equilibrium games, the only difference in choice frequencies between base games and their extensions is driven by level-0 players' behavior, and (b) In coordination games, an increase in choice frequencies of the target strategy in the extensions may be driven by both level-0 players and more sophisticated types. Thus, the model explains our findings if one accepts that: (1) There are no level-0 types in our sample, and (2) Level-1 and level-2 types (and perhaps higher types) *do* appear in the sample and that they anchor their beliefs on the level-0 type's behavior (recall that level-k models are silent regarding the distribution of types in the population). This is consistent with some studies of the level-k model that found that level-0 exists only in the minds of higher types (Costa-Gomes and Crawford, 2006; Crawford and Iriberri, 2007).

The Model's Predictions in Single-Equilibrium Games. In all the games in our experiments, the column players have the same set of strategies in the base games and in their extensions and hence level-0 column players behave the same in both cases. In single-equilibrium games, the column players have a dominant strategy and hence levels-1 players and higher-level types choose it in base games and in their extensions. Taken together, column players of all levels are not affected by the extensions.

As for row players, level-0 choose the target strategy in the extensions with a higher probability than in the base game. For higher levels, each row player makes the same choices across base games and their extensions since column players of all levels do not alter their behavior. Therefore, in single-equilibrium games, the only expected difference between the base games and their extensions is due to the behavior of level-0 row players. Thus, accepting point (1) above, the adapted model can explain our comparative statics in single-equilibrium games, i.e., no difference in behavioral patterns across base games and their extensions.

The Model's Predictions in Coordination Games. In the base games, a level-0 row

[15]Note that in our experiment's setting, the level-0 type specified in the GCH model would behave in a similar manner to our modified level-0 type. However, the underlying psychological mechanism would be different. For example, the increase in choice probabilities of the dominating strategy in the attraction extensions would be due to aversion to minimal payments in the GCH model, while in our model it is due to the salience of that strategy.

[16]Note that we could have made this adjustment to the GCH model and obtain similar outcomes in terms of predictions in our setup.

player chooses either strategy with probability 0.5, and hence a level-1 column player's best response may be either one of the two strategies, depending on his risk preferences. In the extensions, level-0 row players choose the target strategy with a higher probability than in the base game. Consequently, given a belief that a level-0 row player chooses the target strategy with a high enough probability in the extended game, a moderately risk averse level-1 column player who does not choose the target strategy in the base game will choose it in the extended game.[17] Given that some level-1 players "switch" from choosing the safe option in the base game to choosing the target strategy in the extension, level-2 row players choose the target strategy in the extensions with a higher probability than in the base games (the extent to which the target strategy's choice probability of level-2 row players increases, depends on their risk preferences). Since the target strategies support an equilibrium, level-3 column players, level-4 row players, and the corresponding higher levels choose the strategies that constitute that equilibrium with a higher probability in the extension than in the base game.[18]

Thus, the model predicts that level-1 column players choose their target strategy with a higher probability in the extensions than in the corresponding base games. It also predicts more choices of the target strategy for the row player, but not only due to the non-strategic reaction of the level-0 type but also due to level-2 row players who react to the increased choice of the target strategy of level-1 column players.

Taking stock. Table 14 summarizes the qualitative predictions described above in both types of games. The suggested adapted level-k model may explain our findings in both types of games if one accepts that the level-0 type does not exist in our sample but level-1, level-2 (and perhaps higher level types) do show up. Using this framework, the increased choices of the target strategy of both players, which leads to improved coordination on the target equilibrium in coordination games, is due to level-1 column players, level-2 row players and, perhaps, higher level types.

7 Concluding Remarks

We design an experiment to test whether seemingly irrelevant strategies affect players' actions in a manner that violates the standard approach in game-theory. We find that dominated strategies and even more so duplicated strategies affect behavior in coordination games: they highlight one equilibrium over another and facilitate coordination. In single-equilibrium games, these strategies are indeed irrelevant. We conclude that irrelevant

[17]Level-1 column players who are extremely risk averse would choose the safe action, i.e., not the target strategy, in the base games as well as in the extensions. If they are risk neutral or risk seeking, they would choose the target strategy on both occasions.

[18]Note that, as in single-equilibrium games, a level-0 column player behaves the same in the base games and their corresponding extensions. As a result, the hierarchy of types who anchor their belief on a level-0 column player behave similarly in the base coordination games and their extensions.

Table 14: Predictions of Adapted Level-k Model

	Coordination Games	Single-Equilibrium Games
Level-0 row	$p\_base_0^{CG} < p\_extension_0^{CG}$	$p\_base_0^{SG} < p\_extension_0^{SG}$
Level-1 column	$p\_base_1^{CG} < p\_extension_1^{CG}$	$p\_base_1^{SG} = p\_extension_1^{SG}$
Level-2 row	$p\_base_2^{CG} < p\_extension_2^{CG}$	$p\_base_2^{SG} = p\_extension_2^{SG}$
Level-3 column	$p\_base_3^{CG} < p\_extension_3^{CG}$	$p\_base_3^{SG} = p\_extension_3^{SG}$

Notes. Relationship between the choice frequency of the target strategy in the extension and in the base game for the first three hierarchical levels, in coordination games (CG) and single-equilibrium games (SG). The notation $p\_base_k^i/p\_extension_k^i$ represents the frequency with which the target strategy is chosen in base/extension games of type $i \in \{CG, SG\}$ for hierarchical type $k \in \{0, 1, 2, 3\}$.

strategies affect behavior but not through an immediate behavioral reaction to the added strategies, but rather through strategic reasoning and the need for coordination. We suggest an adapted level-k model to explain the observed patterns.

Irrelevant strategies naturally appear in some real-life strategic situations, as in our opening bus line example. Furthermore, they may be intentionally added in strategic interactions by one of the players or by a third party. For example, in different types of negotiations, such as between firms' managements and employee unions, seemingly innocuous irrelevant strategies may affect the outcome of the deliberations in a manner that is highlighted in our work. This allows for sophisticated manipulation by parties through the adjustment of the set of strategies they bring to the table.

Thus, seemingly irrelevant strategies should be taken into account by players, choice designers and even social planners. On the theoretical and predictive front, existing solution concepts of strategic interactions should be enriched in order to account for the relevance of irrelevant strategies.

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Appendix A: Payoff Matrices

For robustness purposes, for each game type we examined four different payoff matrices that slightly varied in their monetary payoffs and in the location of equilibria. The construction of the base games and their extensions followed a set of predetermined rules. Below we describe the main rules alongside a brief explanation of their underlying rationale. The payoff matrices appear in Tables A.1 and A.2.

1. Coordination base games are symmetric which allows for a swift understanding of the base game. The equilibrium payoffs on the other hand are asymmetric, i.e., (x, y) and (y, x) where $x \neq y$.
2. In the extended games, the added strategy generates the same payoff to the column player regardless of his own action. This reduces the potential for direct effects on the column players' behavior so that any effect on the column players is more likely to be a reaction to the expected change in the behavior of the row players due to the added strategy.
3. In the dominance extensions, the last digit of the row player's payoffs in the dominated strategy is different than the last digit of the other payoffs. In addition, the column player's payoff when the row player chooses the dominated option is 10 ILS lower than his lowest payoff in the base game. These features emphasize the domination relation and increase the likelihood that subjects will notice it.
4. In the compromise extensions, when the row player chooses the added strategy, the column player's payoff is equal to his lowest payoff in the base game.[19]
5. Payoffs are multiplications of 5 for clarity and simplicity.

[19] Due to a typographical error, in one of the compromise extensions (game 3) the column player's payoff in the added strategy was slightly below his lowest payoff.

	Base		Dominance Extension		Duplicates Extension		Compromise Extension	
	40,40	**50,80**	40,40	**50,80**	40,40	**50,80**	10,30	**80,30**
Game 1	**80,50**	30,30	35,20	45,20	40,40	**50,80**	40,40	50,80
			80,50	30,30	**80,50**	30,30	**80,50**	30,30
	60,100	50,50	**60,100**	50,50	**60,100**	50,50	**80,40**	20,40
Game 2	40,40	**100,60**	55,30	45,30	**60,100**	50,50	60,100	50,50
			40,40	**100,60**	40,40	**100,60**	40,40	**100,60**
	75,105	65,65	**75,105**	65,65	**75,105**	65,65	**95,45**	25,45
Game 3	55,55	**105,75**	70,45	60,45	**75,105**	65,65	75,105	65,65
			55,55	**105,75**	55,55	**105,75**	55,55	**105,75**
	55,55	**65,95**	55,55	**65,95**	55,55	**65,95**	35,45	**85,45**
Game 4	**95,65**	45,45	50,35	60,35	55,55	**65,95**	55,55	65,95
			95,65	45,45	**95,65**	45,45	**95,65**	45,45

Table A.1: Payoffs of coordination base games alongside their extensions. In every base game the row player's strategies are Top and Bottom while in the extensions, they are Top, Middle and Bottom. The column player has two options – Left or Right. Equilibria in each game are in bold.

	Base		Dominance Extension		Duplicates Extension		Compromise Extension	
	40,40	**50,50**	40,40	**50,50**	40,40	**50,50**	20,40	**60,40**
Game 5	80,80	30,90	35,30	45,30	40,40	**50,50**	40,40	50,50
			80,80	30,90	80,80	30,90	80,80	30,90
	55,55	**65,65**	55,55	**65,65**	55,55	**65,65**	25,55	**85,55**
Game 6	85,85	45,95	50,45	60,45	55,55	**65,65**	55,55	65,65
			85,85	45,95	85,85	45,95	85,85	45,95
	45,45	35,35	**45,45**	35,35	**45,45**	35,35	**55,35**	15,35
Game 7	25,85	75,75	40,25	30,25	**45,45**	35,35	45,45	35,35
			25,85	75,75	25,85	75,75	25,85	75,75
	70,70	60,60	**70,70**	60,60	**70,70**	60,60	**90,60**	20,60
Game 8	50,100	90,90	65,50	55,50	**70,70**	60,60	70,70	60,60
			50,100	90,90	50,100	90,90	50,100	90,90

Table A.2: Payoffs of single-equilibrium base games alongside their extensions. In every base game the row player's strategies are Top and Bottom while in the extensions, they are Top, Middle and Bottom. The column player has two options – Left or Right. Equilibria in each game are in bold.

Appendix B: Instructions

Welcome to the experiment

You are about to participate in an interactive decision making experiment. Please follow the instructions carefully.

In the experiment you may earn a significant amount of money. For your participation you will receive 20 ILS. You may earn an additional substantial amount based on your decisions and the decisions of the other participants in this room.

During the experiment you will play 36 games. In each game you will be randomly matched with another participant as the opponent against whom you will play the game. The game will be presented on your screen and the interaction between you and your opponent will take place through the computer. The identity of your opponents will not be revealed to you during the experiment or after it is completed. In every game you may earn different sums of money depending on your choice and the choice of your opponent. **Upon completion of the experiment, the computer will randomly draw one of the 36 games you played and the amount of money that you earned in that game will be paid to you. Each participant may have a different game chosen for payment.** The choices of your opponent and payoffs will not be presented during the experiment but only upon its completion. Upon completion, you will learn your payoff in each game and which game was chosen for payoff.

Note that since nobody (not even the experimenters) know which game will be chosen for payment purposes, it is best for you to treat every game as if it is the one that counts. The total amount of earnings in the experiment (participation fee and the amount earned in the randomly drawn game) will be paid to you privately in cash immediately after the experiment is completed. We will move on to the payment stage only after all participants finish marking their choices in all games.

It is not allowed to talk during the experiment or to look at other participants' screens. If you have any questions please raise your hand and one of the experimenters will be happy to answer. In most games you will see a table of the following type:

	Left	Right
Up	50,40	10,20
Down	70,20	30,60

One of the participants will be considered the row player and the other participant will be considered the column player. In the game's instructions it will be mentioned if you are playing as the row player or the column player in that game.

The actions described in the rows are the actions that the row player can choose from. In the above table, these are Up and Down.

The actions described in the columns are the actions that the column player can choose from. In the above table, these are Left and Right.

Each player will be asked choose an action without knowing the other player's chosen action. In games in which you are the row player, another participant sees the same table and plays against you as the column player. When you are playing the role of the column player, another participant is playing against you as the row player.

The numbers in the cells of the table represent the ILS amount that each one of you will receive for any combination of your choices. In each cell, the payoff for the row player always appears on the left and the payoff to the column player always appears on the right.

For example, if the row player chose Up and the column player chose Left then the row player will receive a payoff of 50 ILS and the column player will receive a payoff of 40 ILS. If the row player chose Down and the column player chose Right then the row player will receive a payoff of 30 ILS and the column player will receive a payoff of 60 ILS.

In some games you will play the role of the row player and in some games you play the role of the column player.

In any game that you will play, regardless of your role, your payoffs will always be in blue while the payoffs of the other player will be in black. The purpose of the colors is simply to assist you in recognizing your own payoffs. Remember the rule: **Blue is mine, Black is the opponent's**.

A few games in the experiment will be described verbally and will not include a payoff table.

5 Training Games

In the first part of the experiment, you will play 5 training games to make sure that you understand the instructions. You will not receive payoffs for your choices in this training session. Following the training session, you will move on to the 36 games in which you may earn payoffs.