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Iterative Versus Standard Deferred Acceptance: Experimental Evidence*

(Iterative Vs. Standard DA Experiments)

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Abstract

We test experimentally the Gale-Shapley Deferred Acceptance (DA) mechanism versus two versions of the Iterative Deferred Acceptance Mechanism (IDAM), in which students make applications one at a time. A significantly higher proportion of stable outcomes is reached under IDAM than under DA. The difference can be explained by a higher proportion of subjects following an equilibrium truthful strategy under iterative mechanisms than the dominant strategy of truthful reporting under DA. We associate the benefits of iterative mechanisms with the feedback on the outcome of the previous application they provide to students between steps.

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The use of central clearinghouses to match prospective students to universities or schools[1] has been steadily increasing in recent decades, as have the theoretical and empirical studies of the corresponding procedures. The vast majority of these procedures require students to submit rank-ordered lists of universities, and universities to submit rankings (or priorities) over students (often based on the students' exam grades). These submissions are subsequently used to allocate students to universities. One of the primary goals of the designers of these procedures is to ensure the fairness of allocations. Fairness demands that a student is only matched to a less preferred university if all students matched to the one she prefers to her match have higher priority than her. This is especially desirable since priorities are typically based on ability-related measures. In this context, the concept of *stability* becomes a natural objective: an allocation is stable if it is fair, no student is matched to a university she deems unacceptable, and no seat preferred by some student is left empty. Given that designers also account for the incentives induced in the students, they favor strategy-proof mechanisms, i.e., the mechanisms under which truthful reporting of rankings of universities by students is a dominant strategy. The Gale-Shapley Deferred Acceptance (DA) mechanism is often seen as the best mechanism: it is stable, strategy-proof and (constrained) efficient from the students' perspective (Balinski and Sönmez, 1999).[2] One problem, however, is that growing experimental and empirical evidence suggests that participants often misreport their preferences under DA despite truth-telling being a dominant strategy. This may lead to allocations that are not stable.

Bo and Hakimov (2016) recently proposed a mechanism for matching students to colleges, called the Iterative Deferred Acceptance Mechanism (IDAM). Unlike DA, which asks students to submit a rank-ordered list of the universities, IDAM asks students to apply to one university at each step. Universities tentatively retain no more applications than their numbers of seats and if

[1] From this point on, we will refer to the institutions as universities. Unless explicitly stated, all arguments also hold for schools.

[2] In fact, variations of the DA mechanism are used in many real-life student matching programs around the world. College and secondary school admissions in Hungary (Biró, 2012), high school admissions in Chicago (Pathak and Sönmez, 2013) and New York City (Abdulkadiroğlu *et al.*, 2009) as well as elementary school admissions in Boston (Abdulkadiroğlu *et al.*, 2006) are examples of the real-life use of the DA mechanism.

a university receives more applications than it can accept then it rejects the students with lower priorities and retains the remaining applications. After each step, all students are informed of whether their application was rejected or retained. Moreover, the minimum grades among the retained students (cutoff grades) are publicly announced by each university at the end of each step. If an applicant is rejected, she can apply to any other university where the cutoff grade is lower than her grade. Students are not allowed to change their choices while tentatively selected by some university. When the number of steps is large enough, and students have followed the simple strategy of applying to the most preferred college among those available at each step of the IDAM mechanism (denoted the *straightforward strategy*), the matching produced as an outcome is the Student Optimal Stable Matching. This is the matching that is the most preferred by all students among all stable matchings. While, unlike the standard DA mechanism, IDAM does not have a dominant strategy, the authors show that the Student Optimal Stable Matching is an equilibrium outcome under a robust equilibrium concept – Ordinal Perfect Bayesian Equilibrium (OPBE) (Bo and Hakimov, 2016). In a sequential game, a strategy profile is an OPBE if in every period, any deviation strategy is stochastically dominated by following the equilibrium strategy. Though, in theory, IDAM arguably has "worse" incentive properties for students than its direct counterpart (DA), in practice, students might benefit from the iterative nature of the game. Participants might find these procedures simpler to understand or more transparent. Though this hypothesis is not based on a formal notion of simplicity or transparency, it is in line with the evidence from auctions, where direct (sealed-bid) formats are compared to dynamic counterparts, and participants behave closer to equilibrium in the latter. However, the reasons for the behavior being more in line with the theory in dynamic auctions are not well understood, despite being studied for almost 30 years, and thus it is unclear whether the insights of the better performance of the iterative mechanism relative to direct ones could be generalised to other setups. If that is the case, it might have major consequences for the market design field, and matching in particular, where the attention is almost exclusively concentrated on direct mechanisms.

This paper addresses the following questions: Are there benefits of using iterative, non-direct mechanisms compared to the theoretically superior DA? If so, what drives the difference between direct and non-direct mechanisms?

To answer these questions, we run laboratory experiments. Subjects interact with the mechanism for 20 rounds, playing new market parameters (preferences and priorities) in each round. We run three treatments between subjects: DA, IDAM, and IDAM-NC. Unlike in IDAM, in IDAM-NC students do not observe intermediate cutoff grades at every step. Thus, by comparing DA and IDAM-NC we can identify the effect of making the mechanism iterative, while by comparing IDAM and IDAM-NC we can identify the effect of the provision of cutoffs on the students' behavior and on the final allocations. We show that both IDAM and IDAM-NC dominate DA in terms of stability. As for individual strategies, the proportion of truthful (or straightforward) behavior is the highest in IDAM, second highest in IDAM-NC, and the lowest in DA, with all pairwise differences being statistically significant. The biggest improvement comes from making the mechanism iterative, while the improvement due to the provision of the cutoff is significant, but rather small.

Thus, we identify a disparity between the theory and subjects' behavior in the lab: equilibrium predicts subjects' choices better than the weakly dominant strategy. What drives the treatment differences? First, the effect of cutoffs provision is driven by an almost universal adoption of the straightforward strategy by subjects who were rejected at some step of the mechanism and who thus observed intermediate cutoffs. But the most puzzling difference is the improvement of subjects' behavior in IDAM-NC relative to DA, as it is exactly the treatment change which weakens incentive properties, and should thus lead to less truthful behavior. We investigate several alternative explanations for this difference and conclude that the benefit of IDAM-NC relative to DA comes from the feedback on the outcome of the previous actions (rejection from a university) that it provides at each step within a round. This feedback allows subjects to learn when a strategy deviating from truthful behavior does not work as intended, so they can abandon the deviating strategy faster.

The typical deviating strategy from truthful reporting that we observe is essentially the same in all treatments, and we call it the *skipping strategy*. Subjects who play the skipping strategy avoid applying to universities where they think they will be rejected. A subject who plays this strategy selects a university to apply to, expecting no rejections from it. If the subject is rejected from it, in IDAM-NC she learns of it immediately and a mismatch between her expectation and the outcome happens. Due to this mismatch, she might update her belief about how successful the strategy is. If this happens often, she might abandon the strategy in favor of the truthful strategy, which serves as a default strategy. We observe the support for this argument in the data.

We believe that this finding about the drivers of the superior performance of the iterative mechanisms extends to other comparisons of iterative and direct mechanisms. For instance, our argument might be applied to explain the benefit of the English auction relative to the second-price sealed-bid auction. The better performance of the English auction may come not from the fact that players understand it better, but from the fact that during the English auction players quickly realise that a deviating strategy, for instance overbidding, does not work, by observing the hands of other players still up once the clocks are above the player's true value of the object. Note, that previous experimental papers comparing English and second-price sealed-bid auctions did not provide a channel for the benefits of the English auctions, and rather speculate that the presence of "clocks itself" helps: '...The 'real time' nature of the English auction is ideal for producing observational learning, learning without experiencing the punishing effects of actually losing money consequent on bidding in excess of x (the value)' (Kagel *et al.*, 1987, p. 1300). However, Li (2017) recently proposes a theory that explains the difference, as the English auction is obviously strategy-proof, while the second-price sealed-bid auction is not. Note that our argument is different, as we emphasise the importance of the feedback between steps as a source of subjects' learning. Obvious strategy-proofness does not require the English auction to provide this feedback (the information on drop-outs) and thus does not rely on it. Our channel would predict a lower percentage of optimal bidding under the English auction without dropout information, while obvious strategy-proofness would predict no difference.[3] Our argument might be used to explain the better performance of, for instance, the (sequential) Ausubel auction Ausubel (2004) relative to the multiple unit Vickrey auction and the benefit of the uniform price multiple unit English auctions relative to the sealed-bid version, sequential serial dictatorship (SD), when compared to the static SD Li (2017).[4] We elaborate on it in the discussion section.

The contribution of our paper, therefore, goes beyond the matching literature, as it suggests a channel through which learning is happening in the iterative mechanisms, and which could explain the observed superior performance of the sequential allocation mechanisms relative to their direct counterparts. This channel is worth studying further and emphasises the importance of behavioral considerations in market design.

1 Related literature

Our paper is related to the extensive theoretical literature about DA. While strategy-proofness, one of DA's properties, may be considered an element of fairness (Pathak and Sönmez, 2008), it also aligns the students' incentives such that the outcomes have the desirable efficiency and fairness properties. Recent empirical and experimental evidence suggests, however, that those incentives may not be fully understood by the subjects and may lead to assignments that are neither fair nor constrained efficient.[5] Attempts to address the question of how factors outside of the mechanism, such as advice, information on strategies of other players, and communication, affect truth-telling in strategy-proof mechanisms also raise concerns about participants' understanding of incentives

[3] The recent evidence by Breitmoser and Schweighofer-Kodritsch (2018) shows that absence of drop-out information leads to higher rates of deviations from truthful bidding.

[4] In the serial dictatorship mechanism, agents are ordered by an exogenous queue. The first agent in the queue receives her top ranked object, the next agent receives the best ranked among the available ones, and so on.

[5] For results of laboratory experiments comparing the level of truth-telling in DA and other mechanisms, see Chen and Sönmez (2006); Pais and Pintér (2008); Pais *et al.* (2011); Chen and He (2018); Zhu (2015). For evidence based on field data, see Rees-Jones (2018); Hassidim *et al.* (2015); Shorrer and Sóvágó (2017); Chen and Pereyra (2015).

to report truthfully.[6]

Three recent papers also evaluate experimentally non-direct, sequential mechanisms. Echenique *et al.* (2016) consider a two-sided market, with DA being implemented dynamically. Gong and Liang (2016) consider, both theoretically and experimentally, the mechanism currently in use to match students to universities in the province of Inner Mongolia, in China. Although the dynamic mechanism used in Gong and Liang (2016) has some similarities to IDAM, such as the availability of tentative cutoff grades, it is in fact a different mechanism, with different timing and incentives. Klijn *et al.* (2018) compare dynamic versions of both the school-proposing and student-proposing versions of DA to its static counterparts in one-sided settings of the school choice problem. The dynamic version of the student-proposing DA that they implement is equivalent to our IDAM-NC treatment.[7] In contrast to our results, however, Klijn *et al.* (2018) find no statistically significant difference in the proportion of stable outcomes between the standard and dynamic student-proposing DA. We attribute the distinct results to two differences in the experimental setup: the size of the market, i.e., the number of schools or universities, and the information environment. While the market size used in Klijn *et al.* (2018) is four schools and four students, we use markets with eight universities and eight students. Experimental evidence suggests that larger markets (and thus longer rank-order lists) lead to lower truth-telling rates in direct strategy-proof mechanisms, such as DA and TTC (Chen and Kesten, 2015; Hakimov and Kesten, 2018), and thus the larger the market the higher the potential scope is for improvement over DA. Moreover, larger markets make subjects have more interactions with the iterative mechanism within one round, involving, on average, more choices and observations of its operation, emphasizing its contrast with the one-shot nature of DA. Considering the fact that the mechanism used, IDAM-NC, differs from DA essentially in its sequentiality, a larger market is more likely to lead to the differences between the mechanisms. Regarding the information environment,

[6]See Guillen and Hing (2014); Guillen and Hakimov (2018); Ding and Schotter (2017, 2015); Guillen and Hakimov (2017).

[7]Despite the similarities, those experiments in Klijn *et al.* (2018) were performed simultaneously and independently from the ones in this paper.

the difference in the information that subjects have about preferences and priorities might also influence the results: Klijn *et al.* (2018) use complete information, while in our setup there is uncertainty regarding priorities.

Our experiments are also related to the vast experimental literature on auctions, which compares the static and dynamic implementation of different auction formats.[8] Most of the studies confirm that the bidding behavior is closer to that predicted by the theory in dynamic formats than in sealed-bid formats of the auctions, which often suffer from overbidding (see, for instance, Kagel *et al.*, 1987, for one-unit auctions, and Engelmann and Grimm, 2009, for multiple-unit auctions). Kagel and Levin (2001) and Kagel and Levin (2009) compared the sealed-bid multiple items of the homogeneous commodity Vickrey auction to the dynamic uniform price English clock auctions and the Ausubel auction Ausubel (2004). Just like IDAM when compared to DA, the Ausubel auction has a weaker incentive property than the sealed-bid Vickrey auction. More specifically, truthful bidding equilibrium is obtained after the iterative elimination of dominated strategies, while in the sealed-bid Vickrey auction sincere bidding is a dominant strategy. In experiments, however, a higher proportion of sincere bidding is observed in the Ausubel auction.[9]

Finally, our paper is related to the recent paper by Li (2017), which showed in laboratory experiments that subjects follow the dominant strategy in the sequential SD more often than in its static version. He explains the difference through the concept of obvious dominance: in the sequential version of SD, truthful behavior is obviously dominant, while in static SD truthful reporting of the rank-ordered list is a dominant, but not obviously dominant, strategy. Our paper shows that truthful behavior in the sequential version of DA outperforms its direct counterpart, despite not being a dominant strategy, and thus shows that the benefit of sequentialization are not only driven by the stronger theoretical incentive properties.

[8]See an extensive survey of the experimental auction literature in Kagel and Levin (2016).

[9]In section 5 we discuss in more detail the difference between their results and ours.

2 Mechanisms and predictions

In this section we describe the matching mechanisms that we test in the lab. They correspond to the three treatments that we run. At the end of the section we formulate the theoretical predictions for the treatment comparisons.

The student-proposing Gale-Shapley deferred acceptance mechanism (DA)

DA is a direct mechanism. It collects universities' capacities and students' submitted rank-order lists of universities simultaneously, which are used by the algorithm below to produce the final allocation. Universities' priorities over students are strict and exogenously given.[10]

- Step 1: Every student applies to her most-preferred university. Each university rejects the least-ranked students in excess of its capacity and temporarily holds the others.
- Step $k > 1$: Every student who is rejected in step $k-1$ applies to the next most-preferred university according to the submitted rank-order list. Each university pools together new applicants and those who are held from step $k-1$ and rejects the lowest-ranked students in excess of its capacity. Those who are not rejected are temporarily held by the universities.

The process terminates after any step without rejections. Each university is then matched to the students it holds, and students who are not held at any university are left unmatched.

The iterative deferred acceptance mechanism with no cutoffs (IDAM-NC)

IDAM-NC is not a direct mechanism. The allocation procedure is implemented in an iterative way, in which a student applies to one university at a time. After each step a student receives intermediate feedback on whether she was temporarily accepted or rejected at that step. Whenever a student is asked to make a choice, the only restriction is that she cannot choose a university that has rejected her in previous steps. More specifically:

- Step 1: Each student applies to one university. Each university rejects the least-ranked students, among those who applied to it, in excess of its capacity and temporarily holds

[10] Note that for the goal of this study we use students' grades as an instrument to impose priorities.

the others. If no application is rejected, the procedure will stop at this step, matching the universities to the students they hold.

- Step $t > 1$: Each student who is not held at some university applies to any university that has not rejected her in the previous steps in case it exists. If all universities have already rejected her, she is no longer asked to make choices. Each university rejects the least-ranked students, among those held and those who applied to it, in excess of its capacity and temporarily holds the others. If no application is rejected, the procedure stops at this step, matching the universities to the students they hold and leaving students who are not held at any university unmatched.[11]

The iterative deferred acceptance mechanism (IDAM)

Just like in IDAM-NC, the allocation procedure is implemented in an iterative way. Differently from the IDAM-NC mechanism, in the IDAM students are additionally informed about the cutoff values of all universities at the end of each step. Whenever a student is asked to make a choice, she is restricted to choosing among universities with a cutoff grade in a previous step that is lower than her grade. More specifically:

- Step 1: Each student applies to one university. Each university rejects the least-ranked students, among those who applied to it, in excess of its capacity and temporarily holds the others. If no application is rejected, the procedure stops at this step, matching the universities to the students they hold. The cutoffs of each university are made public. For universities where the number of students held is smaller than their capacities, the value of the cutoff by the end of step 1 is zero. For the other universities, the value of the cutoff is the lowest grade among the grades of the students held at each university.
- Step $t > 1$: Each student who is not held at some university applies to any university where the cutoff value is lower than her grade in that university, if one exists. If the cutoffs

[11]Note that subjects in the experiment had to take the decision at each step, with no option of not making a choice.

are higher than her grade at all universities, she is no longer asked to make choices. Each university rejects the least-ranked students, among those held and those who applied to it, in excess of its capacity and temporarily holds the others. If no application is rejected the procedure stops at this step, matching the universities to the students they hold and leaving students who are not held at any university unmatched. The cutoffs of each university are made public.

Given the definitions of the mechanisms, we can now be more specific about the actions taken by subjects following the straightforward strategy under each one of them. In IDAM, it consists of applying to the best university from the preference list among the universities that have a cutoff value lower than the student's exam grade. In IDAM-NC, however, it simply consists of applying to the best university among the universities that have not rejected her.

The summary of treatments and predictions of individual behavior are presented in Table 1. In DA, the truthful submission of a rank-ordered list is a weakly dominant strategy.

The games induced by IDAM and IDAM-NC, however, in general, do not have, a weakly dominant strategy. The reason is that, while at first it may seem like the incentives induced by DA should carry over to those sequential counterparts, the fact that students typically make choices after other students made their own, makes it possible that some of them condition their choices on each other. As a result, there may be situations whereby choosing a less-preferred university, a student triggers actions of one or more other students later on that will end up benefiting her when compared to simply following the truthful strategy.[12]

Despite that, however, all students following straightforward strategies constitutes a "robust" equilibrium (an OPBE), which produces as an outcome the student-optimal stable matching. More specifically, this implies that in any period and sequences of choices made by the participants in previous periods, following the straightforward strategy for the next periods first-order stochastically dominates any other deviating strategy for every student. That is, by following

[12]In the appendix we give a detailed example showing how players' ability to condition their choices on others' actions makes the straightforward strategy not dominant under both IDAM and IDAM-NC.

it the probability of ending up matched to her most preferred university is at least as large as any other deviating strategy, the probability of ending up matched to one of her top two most preferred universities is at least as large as any other deviating strategy, and so on. So while one could argue that strategy dominance constitutes a stronger prediction, a truthful OPBE provides a strong theoretical prediction on a game that does not have it.

Table 1: *Predictions of individual behavior by treatments*

DA	IDAM	IDAM-NC
Truthful reporting (weakly dominant strategy)	Straightforward strategy (OPBE)	Straightforward strategy (OPBE)

Based on these observations, we form the following theoretical predictions:

Prediction 1: The proportion of subjects submitting truthful rank-order lists in DA is higher than the proportion of subjects playing the straightforward strategy in IDAM and IDAM-NC.

Prediction 2: The proportion of student-optimal stable outcomes is higher in DA than in IDAM and IDAM-NC.

Prediction 1 comes naturally from the incentives induced by these mechanisms. While straightforward strategies constitute a robust equilibrium, them being a best response still depends on subjects' belief about other players' strategies. Since a dominant strategy is a best response given any such belief, variations on beliefs may lead to deviations from straightforward strategies, but not from dominant strategies.

While truthful behavior in DA and straightforward strategies in IDAM and IDAM-NC imply stable outcomes, it is possible that stable outcomes are produced without any of these behaviors taking place. Therefore, Prediction 2 is a parsimonious consequence of Prediction 1.[13]

[13]Note that fewer stable outcomes in DA when compared to IDAM and IDAM-NC would require the combination of straightforward behavior and deviating strategies that lead to stable matchings in the iterative mechanisms to be more prevalent than the combination of dominant strategies and deviating strategies that also lead to stable matchings in DA.

3 The Experiment

In this section, we present a series of experiments designed to test DA versus IDAM and IDAM-NC. This experimental design is not the first one we have tried. We originally ran sessions under constant market conditions (the same preference profiles and priorities) and complete information. Our findings were in line with findings of the current experiments from the perspective of stability and efficiency. However, we identified that some of the design choices made did not allow us to observe the effects of the different mechanisms on individual strategies in a robust way, and so we ran additional experiments which are reported here. As this experiment supersedes the previous one, we report the results of the first one in the online appendix.[14]

3.1 Experimental design

In the experiment, there were eight universities that differed in quality and specialization. Each university had only one seat. Universities admitted students based on an exam grade. There were eight students who applied for seats at universities, and each student had a grade for math and a grade for languages. Universities M1, M2, M3 accepted students based on the math grade only. Universities L1, L2, L3 accepted based on the languages grade only. Universities H1 and H2 accepted based on the average grade between math and languages. In all treatments, students received 22 euros if they were matched to their most-preferred university, 19 euros to their second most-preferred university, 16 euros to their third most-preferred university, and so on. Students received 1 euro if they were matched to their least-preferred university. Each treatment lasted for 20 rounds. At the end of the experiment, one round was randomly drawn to determine the participants' payoffs. Each round represented a new market. The preferences used in each market were generated following the designed market idea of Chen and Sönmez (2006). For each market, we generated the qualities of universities uniformly and randomly distributed between [0,40]. It corresponded to the utility of each university for subjects and was common for

[14]The online appendix can be found at http://www.inaciobo.com/research.html.

all subjects. Additionally, for each subject and university we generated a random component of utility from the interval [0,20]. Finally, each subject had an additional utility of 20 for one of the groups of universities: either math, languages or hybrid. This is used to model the student-specific preference for a field of study. The group for each subject was determined randomly. The resulting utilities were transformed into ordinal preferences. The grades were independently drawn, in each round, from the uniform distribution with support [1,100] for math and languages.[15] There is a unique stable matching in all markets except for those used in rounds 8, 14, and 20, where there are two stable matchings.

In the experiment, subjects could see tables with the ordinal preference of all students, as well as the distribution of exam grades, but they could only see the realization of their own exam grade. This design choice was made for the following reasons: complete information about preferences makes it closer to a real-life university admission setup, as by observing the preference table, subjects could have an idea about the popularity of each university. The realizations of the grades of other students were not known, and we argue that this also approximates the informational conditions to university admissions. After each round a subject received feedback about the university in which she had been given a slot, and not the allocation of other students.

We use markets with eight schools, which are relatively large if compared with the experimental literature, for two reasons:

1. There is evidence that a relatively high share (from 65 to 85 percent) of subjects converge to submitting truthfully in DA in markets with three or four schools (Chen and Kesten, 2015, Zhu, 2015) in repeated experiments. However, based on cross-studies observations and evidence in Chen and Kesten (2015)[16] for DA and Hakimov and Kesten (2018) for TTC, we expect lower proportions of truthful submissions in DA when the rank-ordered lists are longer. Thus, we create a larger room for the potential improvement of the iterative

[15] The details of all markets are presented in the online appendix.

[16] The truth-telling rates are lower in the six-school environment than in the four-school environment (75% versus 45% in the last 10 periods).

mechanisms.[17]

2. The large number of schools is crucial for testing the difference between DA and IDAM, as the iterative mechanisms are less sensitive than the direct ones to the increase in the number of universities, as the decision at each step is the submission of just one university from the list.[18]

As mentioned in the previous section we use three treatments: DA, IDAM, and IDAM-NC. The comparison of iterative mechanisms with DA is the focus of the current paper. We use both IDAM and IDAM-NC to disentangle the effect that the provision of cutoff grades during the execution of the mechanism has from the simple iterative nature of the procedure, on both subjects' behavior and the allocation properties.

The experiment was run at the experimental economics lab at the Technical University of Berlin. We recruited student subjects from our pool with the help of ORSEE (Greiner, 2015). The experiments were programmed in z-Tree (Fischbacher, 2007). For each of the three treatments, independent sessions were carried out. Each session consisted of 24 participants that were split into three groups of eight for the entire session. We use fixed groups in order to increase the number of independent observations and allow for maximum learning. We are not concerned about repeated games caveats, due to the fact that every round represents a new environment, and incomplete information does not allow subjects to identify the strategies of the players and their identities in previous rounds.[19] In total, 12 sessions with 288 subjects were conducted. Thus, we have 96 subjects and 12 independent observations per treatment. On average, the experiment

[17] Our markets with eight universities and eight students are the largest markets considered so far in repeated matching experiments: Ding and Schotter (2015) use a market with five students but only four different profiles, Chen and Kesten (2015) with four and six students, Gong and Liang (2016) and Klijn *et al.* (2018) both use markets with four students and four schools, and Zhu (2015) with three students. The only exception is the large-scale experiment by Chen *et al.* (2016). However, the large market in the experiment was created by increasing the number of students with similar profiles, while we create a higher number of different student profiles.

[18] In the case of one school, DA and IDAM are the same, while in the case of 1,000 schools, the submission of the full list in DA is almost unfeasible in practice, while following the straightforward strategy in IDAM still constitutes a simple task at each given step.

[19] Additionally, there are no reputational concerns in the game that could hamper the interpretation of subjects' strategies as one-shot game strategies, given the subjects' experience.

lasted 115 minutes and the average earnings per subject were 25.20 euros, including a show up fee of 5 euros.

At the beginning of the experiment, printed instructions were given to the participants (see the appendix). Participants were informed that the experiment was about the study of decision-making, and that their payoff depended on their own decisions and the decisions of the other participants. The instructions were identical for all participants of a treatment, explaining in detail the experimental setting. Clarifying questions were answered in private. After reading the instructions, the experimenter went through the solution of an example of an allocation task on the whiteboard and allowed for public questions. After that, all individuals participated in a multiple choice quiz to make sure that everybody understood the main features of the experiment.

After the quiz, and before the start of the first round, participants were asked to solve an allocation task which appeared on their computer screens. The solution of the task had to be typed in and, if it was correct, participants earned 2 euros. For the DA treatment, participants were shown the submitted list of virtual students on the screen and their grades and they had to determine the final allocation. For the IDAM and IDAM-NC treatments, participants saw the decision of each student in the first step and had to determine the retained and rejected students in each school. If it was done correctly they were informed about the decisions of the rejected students, and so on until a final allocation was reached. If a mistake was made at any step the task stopped and the solution was counted as incorrect. We introduced the incentivised task to be sure that every participant paid enough attention to the details of the mechanisms and had a measure of the understanding of the mechanics of the mechanisms.

3.2 Results

The significance level of all our results is 5%, unless otherwise stated. We use signs $>$ in the results between treatments to communicate significantly higher.

3.2.1 Aggregate results: Stability and efficiency

In this section, we compare properties of the allocations reached in each of the treatments. We take two perspectives on each of the parameters: learning within treatments and comparison of the outcomes between treatments in the last 10 rounds of the experiment and in all 20 rounds.

Result 1 (Stability):

1. There is a significant increase in the proportion of stable outcomes reached in the last 10 when compared to the first 10 rounds in all treatments.
2. A comparison of average proportions of stable outcomes in the last 10 rounds leads to the following results: IDAM>DA, IDAM-NC>DA. Comparison of the average proportions of stable outcomes in all rounds leads to the following results: IDAM>DA, IDAM-NC>DA.[20]

Support.

The proportions of stable outcomes by treatments and rounds are presented in Panel A of Table 2. We observe a significant increase in the proportions of stable outcomes in all treatments. The average proportion of stable outcomes is significantly higher in IDAM and IDAM-NC than in DA. The difference is significant in both the first 10 and the last 10 rounds of the experiment. Thus, we reject Prediction 2. As for the difference in the number of stable outcomes between IDAM and IDAM-NC, we observe no significant difference. This indicates that the difference regarding stability between DA and two treatments with iterative mechanisms is driven mainly by the iterative nature of these mechanisms, and not by the provision of information about cutoffs. This, to our knowledge, is the first study which shows that DA can be outperformed by another mechanism in a one-sided matching setup from the perspective of stability.

Though the main focus of this paper from the perspective of allocation analysis is stability, as we are motivated by college admissions where priorities have to be respected, we also compare

[20]The result 1 is qualitatively robust to two other measures of stability: the number of blocking pairs, and the number of students with justified envy. In the case of these measures there is a significant decrease in the measures in the last 10 when compared to the first 10 rounds in all treatment; and in the last 10 rounds and all rounds IDAM<DA, IDAM-NC<DA.

Table 2: *Proportions of stable allocations, average efficiency, and truthful strategies by treatments:*

		DA	IDAM	IDAM-NC	DA=IDAM p-value	DA=IDAM-NC p-value	IDAM=IDAM-NC p-value
Panel A: Stable allocations	Round 1-10 (1)	26.7%	54.2%	52.5%	0.00	0.01	0.85
	Round 11-20 (2)	47.5%	76.7%	68.3%	0.00	0.01	0.34
	All rounds (3)	37.1%	65.4%	60.4%	0.00	0.00	0.47
	p-value first10=last10 (4)	0.00	0.01	0.03			
Panel B: Average efficiency	Round 1-10 (1)	97.4%	99.2%	99.4%	0.06	0.03	0.66
	Round 11-20 (2)	98.3%	99.0%	99.4%	0.44	0.27	0.67
	All rounds (3)	97.8%	99.1%	99.4%	0.04	0.01	0.60
	p-value first10=last10 (4)	0.55	0.84	0.97			
Panel C: Truthful strategies	Round 1-10 (1)	41%	59%	54%	0.00	0.01	0.42
	Round 11-20 (2)	55%	82%	74%	0.00	0.00	0.04
	All rounds (3)	48%	70%	64%	0.00	0.00	0.15
	p-value first10=last10 (4)	0.00	0.00	0.00			

*Notes:*Panel A: The probit regression of the dummy for the stable outcome. Panel B: The OLS regression of the average efficiency of allocations. Panel C: The probit regression of the dummy for truthful strategy.
All panels: All the p-values are p-values for the coefficient the dummy for the corresponding treatment (columns 5, 6, 7) or the last 10 rounds (row (4)). The standard errors of all regressions are clustered at the level of the matching groups. Thus, for within-treatment regressions we have 12 clusters (rows (4)), and for between treatments 24 clusters (columns 5, 6, 7).

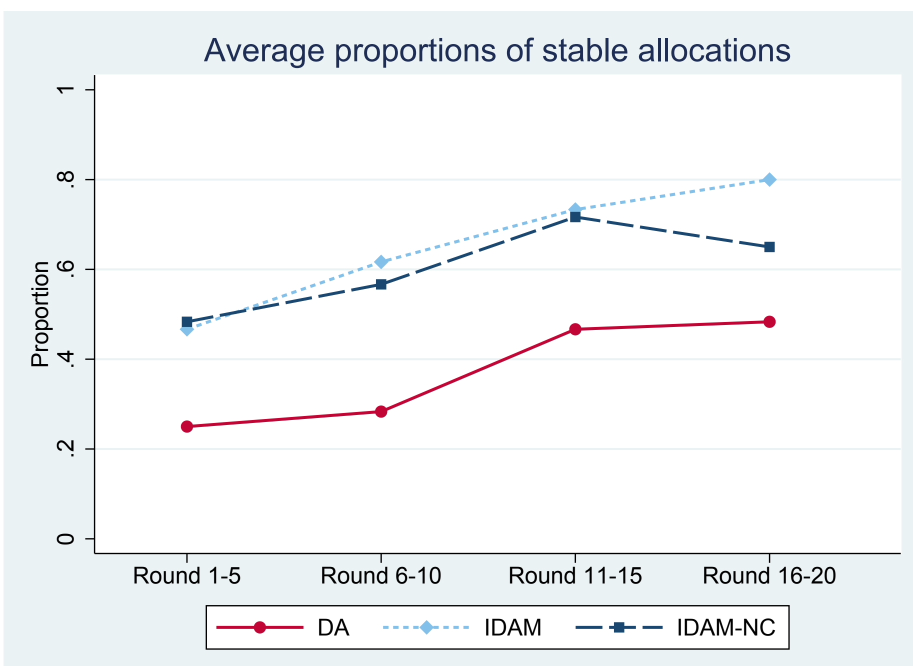

Figure 1: *Proportions of stable outcomes*

the efficiency of the outcomes produced by the mechanisms evaluated. In order to analyze the efficiency of an allocation, we define efficiency as the sum of the payoffs of all the subjects in the allocation produced, divided by the sum of the payoff in the student-optimal stable allocation.

Result 2 (Efficiency): There is no significant difference in efficiency between treatments in the last 10 rounds, but if all rounds are considered, a comparison of the average efficiency leads to the following: IDAM>DA, IDAM-NC>DA.

Support.

Row (4) of Panel B of Table 2 presents the p-values for the significance of the difference in efficiency between the first 10 and the last 10 rounds in each treatment. Efficiency does not differ between the first 10 and the last 10 rounds in any of the treatments. However, the level of efficiency is close to 100%. This can be explained by the fact that not every violation of the stability of an allocation leads to a lower sum of payoffs, and some may even lead to a higher sum of payoffs. As for the between-treatment comparison, in IDAM and IDAM-NC treatments we observe a higher average efficiency than in DA in the first 10 rounds of the experiment. The difference is also significant if all rounds are considered (see columns 5 and 6 of Panel B,Table 2).

3.2.2 Individual behavior

Next, we analyze the individual strategies of experimental subjects in order to test Prediction 1 and better understand the drivers of the observed treatment differences between the proportions of stable outcomes. We consider the proportions of subjects following straightforward behavior in IDAM and IDAM-NC, and the proportion of subjects submitting truthful rank-ordered lists in DA. To simplify the language, we introduce the ***truthful strategy***. A student follows the truthful strategy under DA when she submits the truthful list of all eight universities.[21] In IDAM and IDAM-NC, a student following the truthful strategy is equivalent to her following the

[21] Note that the only undominated strategy, given the information available for subjects taking part in the experiments, is to submit the full truthful list. In our setting there is no "minimum guaranteed allocation," like a district school, for instance, as the grades of the other students are unknown.

straightforward strategy.

The truthful strategy is based on the theoretical properties of the mechanisms. In DA it is a weakly dominant strategy, while in IDAM and IDAM-NC it is an OPBE. It leads to the student-optimal stable matching in all treatments, if played by all subjects of a group.

Result 3 (Behavior in line with the truthful strategy):

1. There is a significant increase in the proportion of subjects behaving in line with the truthful strategy in the last 10 compared to the first 10 rounds in all treatments.
2. The comparison of average proportions of subjects behaving in line with the truthful strategy in the last 10 rounds leads to the following results: IDAM>DA, IDAM-NC>DA, IDAM>IDAM-NC. The comparison of the average proportions of subjects behaving in line with the truthful strategy in all rounds leads to the following results: IDAM>DA, IDAM-NC>DA.[22]

Support:

We observe a significant increase in the truthful strategy play in all treatments, including DA (see row (4) of Panel C, Table 2). Despite the relatively high increase in truthful submissions in DA, the increase of straightforward behavior in IDAM and IDAM-NC is even higher.

Overall, the proportion of truthful strategies is higher in IDAM and IDAM-NC than in DA (see Figure 2, and Panel C, Table 2). The difference is significant for the first 10, last 10, and all rounds jointly. Thus, we can reject Prediction 1. As for the difference between IDAM and IDAM-NC, the proportions of truthful strategies is higher in IDAM, with the difference being significant for the last 10 rounds of the experiment.

Next, we take a closer look at the manipulations in all three treatments.

Result 4 (Truthful strategy violations. Skipping strategy):

[22] Result 3 is robust to two changes of the definition of truthful strategy in DA. First, if instead of requiring the full truthful list we count as truthful all truthful submissions until the student-optimal stable matching for each subject, result 3 remains. Second, if instead of requiring the full truthful list in DA we count as truthful all truthful submissions until the assigned university, result 3 remains.

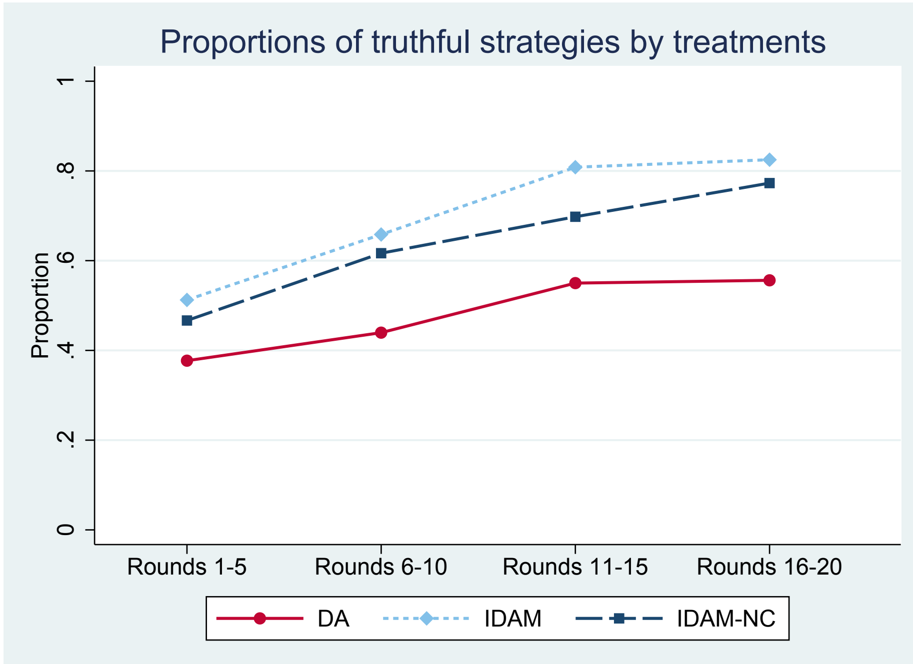

Figure 2: *Behavior in line with the truthful strategy*

1. In all three treatments, the probability of a deviation from the truthful strategy is higher the lower the students' grades are, and if the true top choice is popular among the other students.
2. The skipping strategy is a typical deviation and explains 55%, 72%, and 81% of deviations from truthful strategies in the last 10 rounds in DA, IDAM-NC, and IDAM respectively.
3. The deviations from truthful strategies are costly in all treatments. The average payoff loss equals 2.37 euros DA. In IDAM-NC and IDAM, the average payoff loss is significantly lower than in DA and equals 1.72 euros and 1.60 euros, respectively.

Support: Table 3 presents the marginal effects of the probit regressions of the dummy for truthful strategy play by treatments. In DA we concentrate on the truthful strategy up to assignments (relevant truthful strategy), as we want to focus on the determinants of manipulation at the top of the rank-order lists, to make treatments more comparable. For IDAM and IDAM-NC the truthful and relevant truthful strategies coincide. [23] In all treatments, in line with result 3, the

[23] If one considers full list in DA, the dummy for the popular top choice becomes not significant, other results

probability of playing the truthful strategy increases with the experience and its marginal effect is higher in IDAM and IDAM-NC than in DA. The probability of playing the truthful strategy is also higher the higher the student's grades. The other significant determinant of the truthful relevant strategy is the popularity of the true top choice in one's preferences. We construct a dummy for popular top choice which equals one if the university of the top choice is ranked as a top choice by the highest number of the students. This, together with the fact that the higher the grade the more likely subjects are to play the truthful strategy, points to the tendency of subjects to escape applications to universities with a low perceived chance of being accepted.[24]
We now focus on subjects who play non-truthfully in a systematic manner, namely skipping the choices where they expect to be rejected (with low corresponding grades or popular choices). We refer to it as the "skipping strategy." This deviation from the truthful strategy is the most robust deviation in DA both in experiments and in the field.[25] Subjects use skipping strategies because they want to avoid unnecessary rejections, or because they think that rejections at early steps of the mechanism might hamper their chances in subsequent steps.

While in general skipping strategies include a broad range of strategies, we construct two precise versions of them:

1. Grade-driven skipping strategy: the subject lists as a top choice in DA or applies at the first step of the iterative mechanisms to the university where she has a grade higher than the one for the university of her true top choice.

2. Popularity-driven skipping strategy: the subject does not list as a top choice in DA, or does

are unaffected.

[24]The other significant predictor of truthful strategy is the dummy for the correct solution of the allocation task at the beginning of the experiment. It is positive and significant in IDAM and IDAM-NC, while not significant in DA. It is an interesting finding: if a participant of the experiment was successful in understanding the mechanics of the iterative mechanism from instructions and examples, she is 12.9% and 16.2% more likely to use a straightforward strategy in IDAM and IDAM-NC, respectively. In DA, the fact that a participant of the experiment could produce the allocation of the DA mechanism in the task does not translate into a higher probability of truthful submissions.

[25]Skipping strategy is in line with the district school bias in DA experiments, for details see a recent survey by Hakimov and Kübler (2018), skipping choices in Echenique *et al.* (2016), and the field evidence of Hassidim *et al.* (2015), Artemov *et al.* (2017).

Table 3: *Marginal effects of probit model of submissions in line with the relevant truthful strategy*

	(1) Truthful strategy DA	(2) Truthful strategy IDAM	(3) Truthful strategy IDAM-NC
Round	.015***	.023***	.024***
	(.002)	(.003)	(.003)
Average grade	.005***	.004***	.006***
	(.001)	(.001)	(.001)
Dummy for popular top choice	-.092***	-.058**	-.125***
	(.029)	(.028)	(.030)
Correct solution of the allocation task	-.048	.129***	.162***
	(.076)	(.031)	(.059)
Female dummy	-.005	.008	.057
	(.077)	(.048)	(.064)
Math-related major dummy	.081	.017	.058
	(.070)	(.037)	(.063)
Observations	1920	1920	1920
log(likelihood)	-1232.09	-2159.70	-1095.46

Notes: Standard errors in parentheses, and are clustered on the level of matching groups. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Dummy for popular top choice equal to 1 if the true top choice of a subject is the university which is most often ranked at the top of true preferences of all subjects. Math-related major dummy is equal to 1 if a subject is studying economics, computer science or math, and 0 otherwise.

Table 4: *OLS regression of payoff on the dummy for relevant truthful strategy*

	Payoff
Non-truthful	-2.37***
	(0.16)
Non-truthful in IDAM-NC	0.65***
	(0.13)
Non-truthful in IDAM	0.77***
	(0.20)
Dummies for each student ID in each round	(yes)
Observations	5760
R^2	0.79

Notes: OLS regression. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered on the level of matching groups and are presented in parentheses. Non-truthful is a dummy for not playing the truthful strategy. Non-truthful in IDAM-NC is the interaction of the Non-truthful dummy and the dummy for IDAM-NC treatment. Non-truthful in IDAM is the interaction of the Non-truthful dummy and the dummy for IDAM treatment.

Figure 3: *Truthful and skipping strategies*

not apply at the first step of the iterative mechanisms to a university, if this university is the most popular top choice according to the true preferences of all students.

Thus, we concentrate only on the top choices of the subjects, as in this case both popularity and grade-driven skipping are easy to define. Figure 3 presents an area-plot of strategies by treatments and rounds. The light blue area represents the proportion of truthful strategies, and thus replicates the information in Figure 2. The red area represents the proportion of non-truthful strategies which are in line with grade-driven skipping. The dark-blue area represents the proportion of non-truthful strategies which are in line with popularity-driven skipping and are not in line with grade-driven skipping. There is a significant decrease of grade-driven skipping and popularity-driven skipping in all treatments when comparing the first 10 rounds of the experiment to the last 10 rounds ($p<0.01$, p-values for the coefficient of the dummy in the probit regression of the dummy for using the respective skipping strategy on the dummy for the last 10 rounds with the clustered standard errors on the level of the matching groups). Moreover, as is evident from the graph, the biggest improvement in terms of truthful strategies comes from the decrease in skipping strategies.

Skipping strategies rely on the subject's beliefs about the chances of being rejected from a certain university. If these beliefs were correct, the deviation from truthful strategy to skipping strategies would not lead to any loss in the subjects' payoffs. Next, we study how costly these deviations are for subjects from an individual perspective. Table 4 presents results of the OLS estimation of the effect of misreporting on the payoff of the subjects.

The regression includes 160 dummies for each combination of ID and round, to account for the "role-specific" fixed effects, as the roles (combination of preferences and grades) vary the prospects of earning high payoffs. Thus, the coefficient for the non-truthful dummy presents the average differences between subjects who play truthfully relative to subjects who play non-truthfully in DA, controlling for the role of the subjects. In DA, misreporting on average leads to a loss of 2.37 euros (note that maximum payoff for the allocation is 22 euros), while the deviations are 65 cents less costly in IDAM-NC and 77 cents less costly in IDAM.[26] The difference can be explained by the fact that skipping in iterative treatments is more often non-consequential for the payoff than in DA.

4 Reasons for the superior performance of the iterative mechanisms

In this section we consider possible reasons for the treatment differences. We start the section by looking deeper into the reasons for the positive effect of the provision of cutoffs, and continue with possible explanations for the effect of the sequentialization.

[26] Unfortunately, we cannot run simulations to have a clear understanding of whether some manipulations were the best response to the strategies of other players. While it would be possible to verify whether students who are not submitting truthful preferences under DA are best responding to their counterpart strategies, that analysis is not possible under both the IDAM and the IDAM-NC mechanisms. The reason is that, in sequential games, strategies are themselves functions that specify different actions for each configuration an agent may face at a given step. Therefore, knowing how other agents would respond to a counterfactual strategy is something that requires more information that can be observed in the experimental setting. Thus, the rates of deviations from the straightforward behavior are just suggestive measures of the proportions of subjects who actually fail to best respond.

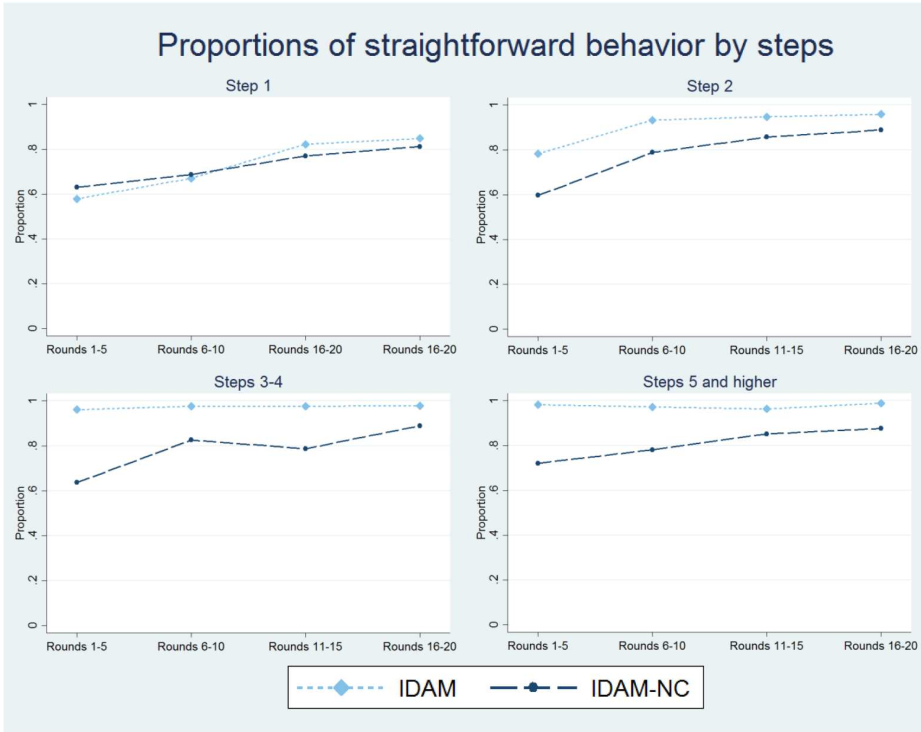

Figure 4: *Behavior in line with the straightforward strategy*

4.1 The effect of the provision of cutoffs

Next, we take a closer look at the differences in straightforward behavior between IDAM and IDAM-NC. Figure 4 presents the average proportions of straightforward behavior by groups of five rounds in IDAM and IDAM-NC, depending on the step of the mechanism. Decisions in step 1 are the first decisions, and being straightforward requires choosing the most-preferred university. There is no significant difference between IDAM and IDAM-NC in terms of the proportions of truthful most-preferred university submissions (see column one of Table 5).

Decisions in steps 2 and 3 are taken after one and two rejections, respectively.[27] Due to the simple fact that the number of options available after each step in IDAM is weakly smaller than

[27]Note that in IDAM straightforward behavior requires the application to the best university among those available given the published cutoffs. In IDAM-NC subjects are not aware of the cutoffs, and thus straightforward behavior requires applying to the best university among those that have not rejected the subject in the previous steps. If a subject applied to the true top choice in the first step, straightforward behavior requires the application to the second-best university at the second step. If the subject did not apply to the true top choice at the first step, straightforward behavior requires the application to the true top choice at the second step.

Table 5: *Marginal effects of the probit model of straightforward submission depending on the average grade by cycles of the mechanism.*

	(1) Straightforward step=1	(2) Straightforward step=2	(3) Straightforward step=3 or step=4	(4) Straightforward step>4
Round	.017***	.014***	.007***	.010***
	(.002)	(.002)	(.002)	(.002)
IDAM	.007	.138***	.093***	.098***
	(.041)	(.045)	(.026)	(.026)
# of available options		.007	-.044***	-.051***
		(.011)	(.008)	(.008)
Observations	3840	1896	1962	1782
log(likelihood)	-2107.61	-746.96	-684.37	-710.12

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered on the level of matching groups and are presented in parentheses. # of available options represents the number of universities with corresponding cutoff grades being lower than the student's at the moment of decision in IDAM, and equals the number of schools that have not rejected the student before the current step of the mechanism.

under IDAM-NC, the likelihood of a behavior being consistent with a straightforward strategy, by pure mechanics, is greater under IDAM than under IDAM-NC. To control for that fact, we added the number of options available to the student at each step to the regression.

Starting from step 2, the probability of straightforward behavior is significantly higher in IDAM than in IDAM-NC, controlling for the number of options available (see columns 2, 3, and 4 of Table 5). In IDAM, starting from the second step, participants see the cutoffs and thus some uncertainty about the availability of universities is resolved, and therefore subjects do not need to form beliefs about universities where they have a chance of being accepted. Thus, skipping the application to the university with a cutoff lower than the respective grade of the subject is harder to justify.

Thus, the improvement in the proportion of truthful strategies in IDAM relative to IDAM-NC is explained by an almost universal adoption of the straightforward behavior by the subjects after the first rejection, once the cut-off grades of universities are published.[28]

[28]Note that this improvement in truthful strategies does not translate into significant differences in stability relative to IDAM-NC. This is because the mistakes of the first choice are often the most consequential for stability, and in the first choice both iterative mechanisms are equivalent. In IDAM, among those who were not truthful and were accepted at the first step of the mechanism and not rejected later, 59% experience justified envy, while this percentage is, on average, 27% for those who were accepted at later steps. Moreover, part of the difference

4.2 Direct versus iterative deferred acceptance

Why do subjects converge faster to truthful behavior in iterative mechanisms than in the direct mechanism? In this section we devote particular attention to the difference between DA and IDAM-NC, as these treatments differ only in the dimension of iterative implementation, and thus strategies are directly comparable up to the assigned university.[29] As for IDAM, we list results only when a meaningful comparison is possible, but due to the restriction of options starting from the second step of the mechanism, strategies of DA and IDAM-NC are not comparable to the strategies in IDAM, and thus we do not present them. We present three possible explanations for the differences between the iterative and direct mechanisms, and provide data from the experiments either supporting or contradicting the explanation.

4.2.1 Is it about the difference between the complexity of reporting a rank-ordered list and of choosing one university at a time?

In IDAM-NC, subjects make decisions about only one university at a time. This is not the case in DA, as subjects have to consider all possible realizations of the mechanism and plan which university to rank at which position in the rank-ordered list. If subjects think step by step when submitting the lists in DA, the reporting becomes more complex the further down the rank-ordered list they go.[30] In the case of the decision about the top choice, the decision is simple, because it is clear when and how the mechanism will use this choice. When making a decision about the second choice in DA these subjects would try to understand the procedures inside of the mechanism that would lead to the use of the second reported choice and, based on that, would

in truthful strategies in IDAM-NC is non-consequential, as some subjects return to truthful behavior within the round, after non-consequential, non-truthful choices during the first steps of the mechanism.

[29] Note that we observe the strategies of subjects below the assigned university only in DA

[30] This would be in line with Schotter *et al.* (1994) who showed that subjects behave differently in the normal and extensive games with the same set of equilibrium outcomes. One can argue that DA can be compared to the normal form game presentation, while IDAM-NC to the extensive form game representation. In DA, subjects submit rank-ordered lists and thus have to pick a strategy for every node of the game at once, while in IDAM-NC they can think about every node separately.

decide which university to report as the second choice. This requires contingent thinking. The third choice is even harder. If a subject has a limited capacity for contingent thinking, or a limited understanding of the mechanics of how DA works, she is likely to be able to make a correct or "truthful" report at the top of the lists before deviating from truthful behavior in the subsequent choices.[31] In IDAM-NC, subjects always report only one university at each step at a time, and might thus make fewer mistakes. This implies that the percentage of truthful decisions should not depend on the step, and the differences from DA would be explained by more thought-through later choices relative to lower-ranked reports in DA. This, however, contradicts the data, as the biggest difference between DA and IDAM-NC comes from the submission of the relevant top, and relevant top two choices.[32]

Thus, we can conclude that the difference in the proportion of truthful strategies between the iterative mechanisms and DA cannot be explained by the arguments above.

4.2.2 Experience

As subjects take more decisions within each round in the iterative mechanisms, it might be that this leads to better learning of the equilibrium strategy. We thus conjecture here that the need to take a decision makes subjects think more about the mechanism, and they thus understand it better after each decision. Subjects take only one decision per round in DA, and up to eight decisions in the iterative mechanism.[33]

One of the problems with identifying the effect of experience in the iterative mechanism is that the number of decisions is highly correlated with the propensity of being truthful (significant Spearman correlation is 0.28 and 0.33 in IDAM-NC and IDAM respectively, $p<0.01$). Note that

[31] An alternative way to think about it would be a limited attention approach, where subjects can concentrate on what to report at the top of the rank-ordered list, but their attention is split toward the bottom of the list.

[32] Figure C.1 in Appendix C presents the proportions of truthful reporting grouped by the length of the list, relevant for the allocation in DA and IDAM-NC.

[33] Note that we abstract here from the fact that decisions are different between treatments: in DA, a decision corresponds to a submission of a rank-ordered list, while in IDAM-NC and IDAM a decision corresponds to a choice of a university.

if subjects play skipping strategies they are more likely to be involved in a smaller number of decisions within each round, as they skip universities with low perceived chances. The only exogenous variation that we can explore is that the subjects who made the same choices ended up having to make a different number of decisions due to different behavior of the opponents. Unfortunately, we do not have enough data which satisfies this condition precisely. If we assume that the number of decisions by all subjects who did not play the truthful strategy is exogenous and determined by other players, we can run a probit regression of the dummy for playing the truthful strategy for the first time, depending on how many decisions the subject has previously taken.

Table 6 presents the marginal effects of the probit model for the dummy of playing in line with the truthful strategy in IDAM-NC, only for subjects who never played the truthful strategy in the previous rounds. Model (1) considers only the second round, with the sample restricted to subjects who did not play the truthful strategy in round 1. Model (2) looks at round 3, with the sample restricted to the subjects who did not play the truthful strategy in rounds 1 and 2. Model (3) looks at round 4 strategies for those subjects who did not play the truthful strategy in the first three rounds. In all models, the number of decisions taken in the previous rounds does not have a significant effect on the probability of playing truthfully in the current round.

This suggest that the benefits of the IDAM-NC relative to DA is unlikely to be driven just by a higher number of decisions.

4.2.3 Directed learning within rounds and correction of mistakes

In this subsection, we explore the difference between DA and IDAM-NC using the fact that the iterative mechanism allows subjects to change their strategy within a round, and that their decisions about all but the first choice are made given the information that they were rejected in the previous choices. We have, so far, identified two types of strategies that subjects adopt – the truthful strategy and the skipping strategies. We want to understand what makes subjects

Table 6: *Marginal effects of the probit model for the dummy of truthful strategy plays depending on the number of decisions taken in all previous rounds in IDAM-NC*

	(1) Truthful strategy round 2	(2) Truthful strategy round 3	(3) Truthful strategy rounds 4
Number of decisions taken	.02	.03	.02
	(.02)	(.02)	(.03)
Dummy for popular to choice	.07	.21	
	(.08)	(.21)	
Average grade	.00*	.02***	.03***
	(.00)	(.00)	(.01)
Observations	60	52	29
No. of clusters	12	12	10
log(likelihood)	-22.00	-19.34	-12.67

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered on the level of matching groups and are presented in parentheses. Sample is restricted to subjects who did not play the truthful strategy in any of the previous rounds. Number of decisions taken is equal to the number of decisions taken in all previous rounds.

abandon skipping strategies in favor of truthful strategies in IDAM-NC and not in DA. Because subjects take multiple decisions within one round of IDAM-NC, they have a chance to update the belief about how successful the strategy is before every decision. This update is possible due to the feedback of the rejection from the previous application. This is not the case in DA, as the update of belief about how successful the strategy is can happen only after the end of the round. This might be crucial for abandoning the use of skipping strategies.

First, we think of the truthful strategy as a strategy that is either played by subjects who understand the mechanism well or by subjects who have failed to find a better strategy for how to outsmart the other players. Now, consider a subject who thinks that a skipping strategy is a better alternative to the default truthful strategy. Instead of being truthful, this subject tries to find a university where she has a high chance (non-popular university or the university for which her grade is high). She will put the university at the top of the rank-ordered list in DA and will apply to it at the first step of IDAM-NC. Thus, the skipping strategy implies fast acceptance: in IDAM-NC it means acceptance at the first step of the mechanism, while in DA it means acceptance to the top submitted choice.[34] What happens if the subject's belief about the chances at the university which was put on top of the list in DA or applied at the first step in IDAM-NC were correct? The subject will never be rejected from the university in IDAM-NC and will learn that she received the seat at this university in DA. Thus, the subject's expectations will be realised, and this might reinforce the belief that the skipping strategy is the correct one. What happens if the subject's belief about her chances in the university which was put on top of the list in DA or applied at the first step in IDAM-NC were wrong? In DA, the subject will learn that the assignment is different from expected, and she would have to think of possible reasons for it. Potentially, the subject might update her belief about how successful the skipping strategy is. In iterative mechanisms, however, after the subject is rejected by the university, she is allowed to restrategise. Every time the expectation of being accepted at a certain university is not matched, a subject might update her beliefs regarding how good the skipping strategy is, as every rejection highlights that the skipping strategy does not work as intended.[35] In this respect there is an asymmetry between the iterative mechanisms and DA: there may be multiple failures of the skipping strategy in one round in the iterative mechanism and only one in DA. Thus, the probability that subjects will be "disappointed enough" to abandon the skipping strategy in favor of the default truthful strategy is higher in the iterative mechanisms. There is another asymmetry between DA and the iterative mechanisms: it is demanding and requires the backward counterfactual thinking to realise the mismatch of expectations from a skipping strategy in DA from the feedback of being allocated in the choice listed below the expected one, while in the iterative mechanisms the feedback and the mismatch are salient and immediate.

[34] Being precise, the skipping strategy might include up to X universities, and not only one. This would mean that the subject puts a set of X universities at the top of the rank-ordered list or plans to apply to these universities one after the other in IDAM-NC. A skipping strategy is "partial" in the sense that it does not include all possible sequences of choices/iterations, but is based on the belief that the outcome will be one among X first-choices in iterative mechanisms or top-ranked in DA. Therefore, in the iterative mechanisms there is no plan for what to do if this belief is incorrect, and in DA there is no clear reasoning behind the ranking below those X elements. For simplicity, we concentrate on the extreme case of the skipping strategy consisting only of one university, but the argument easily extends to the set of X universities.

[35] The subject might understand that skipping or "fast application" does not bring advantages in terms of chances of acceptance.

We are unable to test this argument precisely in the data, as in the data we cannot identify with certainty the subjects who used the skipping strategy and were disappointed with it. But we argue that the switch from skipping to straightforward choices within a round might point to subjects who realised the failure of the skipping strategy during that round.[36] If the argument above is correct, these subjects should be more likely to play truthfully in the following rounds relative to those who never abandoned the skipping behavior and were assigned to one of the expected choices. Thus, we construct a variable "proportion of consecutive straightforward choices before the last within a round." It equals the number of consecutive straightforward choices until the last by a subject in a round, divided by the total number of choices made by that subject within this round. For IDAM-NC, at the first step, to be straightforward, the choice must be the most-preferred university. If the choice at the first step was not straightforward, then all subsequent choices will not be straightforward until the subject applies to the true most-preferred university. For the rounds of truthful strategy play, this variable is always equal to 100%. If subjects used the skipping strategy and it was successful, this variable equals 0%. Intermediate values of this variable point to subjects who started the round using skipping strategies and went back to the skipped choices later on. Moreover, these subjects were truthful in all subsequent choices until they were accepted. Thus, the higher the proportion of straightforward choices is, the more likely it is that the subject realised the failure of the skipping strategy early in the round.[37] This variable was constructed for DA, taking the similar "iterative reasoning" for the reporting of the top, second, third choice, and so on, one after another. To be straightforward, the x-th reported choice must report the best university among the subset of those not reported in the first until the

[36]In IDAM-NC, if a subject starts the round by skipping, let us say directly to the third choice, she will never have a straightforward choice before she actually "returns" to the skipped true top choice, as that will be present in her choice set of the universities in all consecutive steps of the round. We think that the fact that a subject, after trying to apply to lower-ranked universities, returns to the true top choice, might point to the switch of the strategy. However, we require these subjects to be consistently straightforward until the last choice of the round.

[37]Note that earlier switches (after only a few rejections) are more likely to signal the disappointment in the skipping strategy than later switches, where the return to the skipped choices might just be mechanical, due to the rejections from other choices. That is why we use a continuous measure of proportion, and not a binary measure of the presence of the straightforward choice in a round.

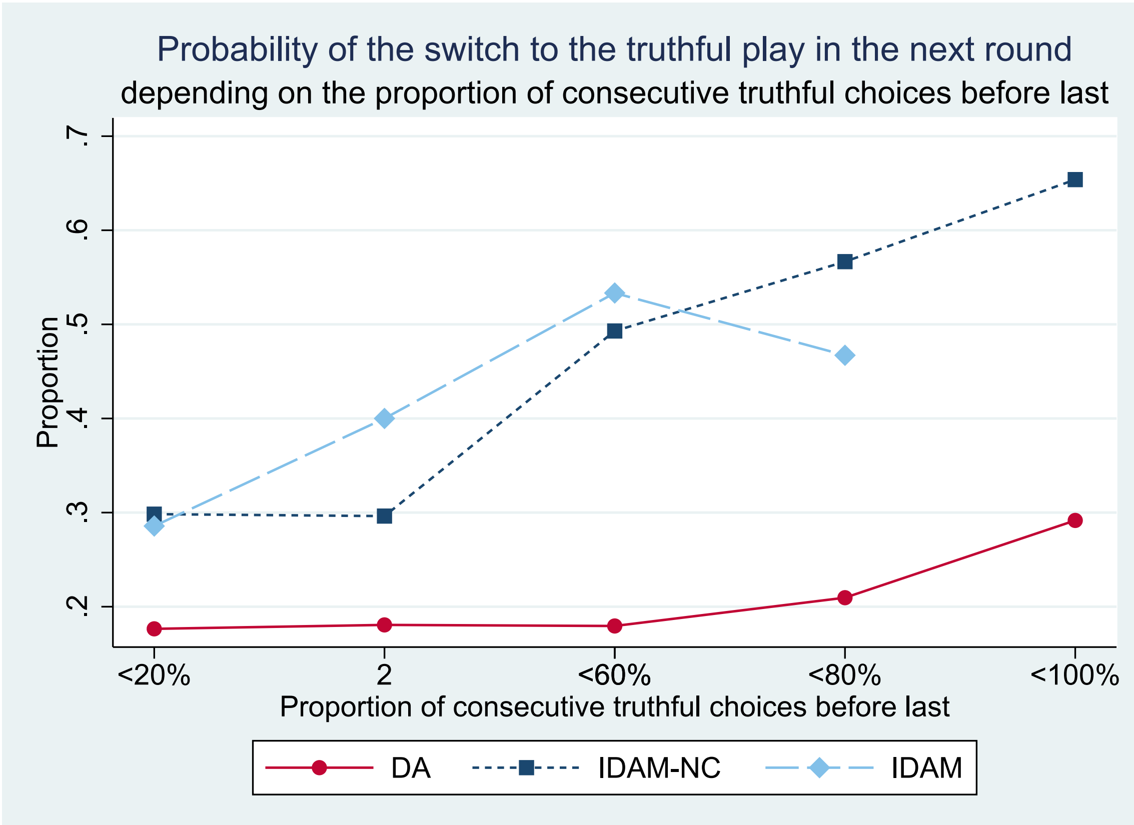

Figure 5: *Proportion of switches of strategies from non-truthful to truthful depending on the proportion of consecutive straightforward choices before last in a previous round*

(x-1)th choices. For IDAM, straightforward choice means something slightly different, as subjects can only choose from a subset of universities that have a tentative cutoff lower than the subject's corresponding score. Thus, the comparison of IDAM with other treatments should be made with caution. We restrict our attention to the rounds in which a subject did not play truthfully. We further restrict our sample to the case when a subject was not assigned to the reported top choice, as in these rounds the proportion of straightforward choices is always zero, and no learning of the failure of the skipping strategy is possible.[38]

The probability of switching to the truthful strategy in the next round increases with the proportion of consecutive truthful choices before the last in the previous round in IDAM and

[38]The proportion of truthful strategies played in the next round, after being assigned to the non-truthful reported top choice is 26% in DA and 23% in IDAM-NC.

IDAM-NC, see Figure 5.[39] This observation is in line with the argument that the within-round "return" of subjects to the truthful (previously skipped) choices can indicate disappointment with the skipping strategy. For the statistical analysis, consider Table C.1 in Appendix C. In line with the graphical evidence in Figure 5, the proportion of consecutive truthful choices is significant in IDAM and IDAM-NC, and not DA, controlling for other variables.

Therefore, the data are consistent with the argument that the benefit of iterative mechanisms comes from the feedback these mechanisms provide within a round: information on the outcome of the previous actions, own or of the other players, teaches subjects that the deviation from truthful behavior did not work as intended.

At this point, it is worth noting how this argument relates to the concept of obvious dominance. Li (2017) defines a strategy as obviously dominant if, for any deviation, at any information set where both strategies first diverge, the best outcome under the deviation is no better than the worst outcome under the dominant strategy. Note, that the straightforward strategy is not a dominant strategy, and is thus not obviously dominant. So what drives agents toward straightforward strategies under IDAM and IDAM-NC is not related to that concept. Instead, our argument relies on the feedback that players who deviate from the equilibrium strategies may receive. Mechanisms with obviously dominant strategies, on the other hand, may not provide such feedback.

Summing up this section, we conclude that the data suggest that the benefits of iterative mechanisms come from the between-steps feedback and the possibility to restrategise. The feedback helps subjects to realise when non-equilibrium strategies do not work, and thus they abandon them in favor of the default truthful equilibrium.

[39] We grouped the subjects into the categories, depending on the value of the proportion of the consecutive truthful choices before last.

5 Discussion

Our findings demonstrate that the benefits of iterative mechanisms relative to their direct counterparts go beyond different auction formats. We suggest that the source of the benefits in our context comes from learning about the effects of deviating strategies due to the between-steps feedback. This channel is novel and is not trivial: it is not about the "simplicity" of learning the equilibrium strategies of the mechanisms, but about the "simplicity" of participants realizing the failure of deviations from the equilibrium strategy of being truthful. We believe the argument extends to other comparisons between iterative and direct mechanisms.

For instance, our argument might be applied to explain the benefit of the English auction relative to the second-price sealed-bid auction. The better performance of the English auction may not come from the fact that players understand it better, but from the fact that during the English auction, players quickly realise that a deviating strategy, for instance overbidding, does not work. Imagine, for example, a player who decides to bid \$1,100 given her true valuation of the object is \$1,000. She does so as she expects that this would lead to a higher probability of winning while the price is still below \$1,000. Under the second-price sealed-bid auction she would send a bid of \$1,100. Under the English auction she starts the auction with the intention of keeping the hand raised until the price reaches \$1,100. If after some time she observes other players holding their hands up at a price higher than \$1,000, however, it becomes obvious to her that the strategy did not work as intended, since the price of the object became higher than she expected. Once this is realised, she would then immediately put her hand down. Thus, we can expect an almost immediate learning that overbidding does not work. Note that Li (2017) presented another explanation for the difference in behavior observed in the lab: while the English auction is *obviously strategy-proof*, the second-price sealed-bid auction is not.[40] That, however, cannot

[40]Note that by obvious dominance the player will realise that the price will be higher than \$1,000 when the clock reaches \$1,000 independent of observing the other players with raised hands, while for our argument this observation is crucial.

be used to explain our results between IDAM-NC and DA (neither explain the results of Kagel and Levin, 2001, and Kagel and Levin, 2009). Recent evidence by Breitmoser and Schweighofer-Kodritsch (2018) shows that the obvious strategy-proofness property of the English auction does not account for the main improvements relative to the second-price sealed-bid auctions, while the explanation of the process in the interactive manner (clock) and the feedback about the number of current bidders provide significant improvements. This is in line with our suggestive evidence.

The better performance of the (sequential) Ausubel auction relative to the multiple unit Vickrey auction and the benefit of the uniform price multiple unit English auction relative to the sealed-bid version can be explained by a similar argument. In fact, it is evident from Kagel and Levin (2001) and Kagel and Levin (2009) that the advantage of these dynamic auctions comes from the information about dropouts, and not from the fact that it is sequential. At first sight this might seem to be as a contradiction to our results, but in fact it supports our explanation: in order to outperform the direct counterpart, the sequential mechanism must provide intermediate feedback on the actions of other players. The Ausubel and multiple unit uniform price English auctions without dropout information as tested by the authors is not truly sequential in this sense: it is just a different framing for bidding in the sealed-bid auction. The analogue of it in our case would be an implementation of DA in which subjects are sequentially asked for the top, second, and other choices. These sequentially elicited choices are then transformed into rank-ordered lists to be used in DA. That is, at no point would the participants receive any feedback on the feasibility of their choices. We conjecture that this mechanism would not improve upon DA.

Another example of an iterative mechanism that performs better than its static counterpart in experiments is the sequential SD (Li, 2017). In fact, SD is a simple, direct mechanism, and deviations from truthful reporting are not observed very often. The typical manipulation is done by subjects who have a lower priority. These subjects manipulate submitted rank-ordered lists of objects, putting at the top of the list the objects that they guess would be the best among those available in their turn. This is closely related to the skipping strategy in DA. In the sequential

SD subjects take turns and just choose the object to keep, once their turn is realised, without submitting any rankings beforehand. A subject who at the beginning of the sequential SD has a similar strategy to that of skipping in mind and who guesses the object correctly would not learn anything, but if there is a better object available in the choice set at the moment of her decision, she would learn that the strategy is wrong and will thus choose the better object.

While our explanation is suggestive, we believe it provides a good start for further exploring the source of benefits of the sequential mechanism relative to the direct counterpart in the broader context, and with the help of treatment variations. This is of great importance, as it can provide guidance to market designers, guided not only by theoretical concepts, but also by evidence of systematic deviations from theoretical predictions.

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A Lack of dominance of straightforward strategies in IDAM and IDAM-NC

Consider the following problem. There are five students $S = \{s_1, s_2, s_3, s_4, s_5\}$ and five universities $C = \{c_1, c_2, c_3, c_4, c_5\}$, each with a capacity of only one student. The students' preferences and universities' priorities are as follows:

$$
\begin{array}{ll}
P_{s_1} : c_3 \; c_2 \sim & P_{c_1} : s_3 \; s_1 \; s_2 \;\sim \\
P_{s_2} :\sim & P_{c_2} : s_2 \; s_1 \;\sim \\
P_{s_3} : c_5 \; c_4 \; c_1 \;\sim & P_{c_3} : s_2 \; s_1 \;\sim \\
P_{s_4} : c_5 \; c_4 \;\sim & P_{c_4} : s_4 \;\sim \\
P_{s_5} : c_5 \;\sim & P_{c_5} : s_5 \;\sim
\end{array}
$$

In order to show that straightforward strategies are not dominant, it suffices to show a strategy profile for all students and show that there is a student who can obtain a better outcome by using a different strategy than a straightforward one.

Assume that students s_3, s_4 and s_5 follow straightforward strategies, but s_2 uses the following strategy:

- Apply to university c_1.
- If rejected from c_1 in the first step, apply next to c_2.
- If rejected from c_1 in a step after the first, apply next to c_3.

We will show that student s_1 obtains a better matching by using a strategy different than the straightforward. If s_1 follows the straightforward strategy, this is the sequence of actions that take place under both the IDAM-NC and the IDAM mechanisms:

1. Step 1: Students s_3, s_4 and s_5 apply to c_5. Student s_1 applies to c_3 and student s_2 applies to c_1. Students s_3 and s_4 are rejected.
2. Step 2: Students s_3 and s_4 apply to c_4. Student s_3 is rejected.
3. Step 3: Student s_3 applies to c_1. Student s_2 is rejected.
4. Step 4: Since she was rejected in the third period, student s_2 applies to c_3. Student s_1 is rejected.
5. Step 5: Student s_1 applies to c_2 and is accepted.

Therefore, if student s_1 follows the straightforward strategy, she will be matched to her second most-preferred university.

Suppose now that instead of following the straightforward strategy, student s_1 first applies to c_1 and then, if rejected, to c_3. This is then the sequence of actions that take place under both the IDAM-NC and the IDAM mechanisms:

1. Step 1: Students s_3, s_4 and s_5 apply to c_5. Students s_1 and s_2 apply to c_1. Students s_2, s_3 and s_4 are rejected.
2. Step 2: Students s_3 and s_4 apply to c_4. Since she was rejected in the first period, student s_2 applies to c_2. Student s_3 is rejected.
3. Step 3: Student s_3 applies to c_1. Student s_1 is rejected.
4. Step 5: Student s_1 applies to c_3 and is accepted.

If student s_1 follows this deviation from the straightforward strategy, she will be matched to her most-preferred university, an outcome that is better than when she follows it. Therefore, the straightforward strategy is not dominant under both the IDAM and the IDAM-NC mechanisms.

B Instructions of the experiment

Welcome! This is an experiment about decision-making. You and the other participants in the experiment will participate in a situation where you have to make a number of choices. In this situation, you can earn money that will be paid out to you in cash at the end of the experiment. How much you earn depends on the decisions that you and the other participants in the experiment make.

These instructions describe the situation in which you have to make a decision. The instructions are identical for all participants in the experiment. It is important that you read the instructions carefully so that you understand the decision-making problem well. If something is unclear to you while reading, or if you have other questions, please let us know by raising your hand. We will then answer your questions individually.

Please do not, under any circumstances, ask your question(s) aloud. You are not permitted to give information of any kind to the other participants. You are also not permitted to speak to other participants at any time throughout the experiment. Whenever you have a question, please raise your hand and we will come to you and answer it. If you break these rules, we may have to terminate the experiment.

Once everyone has read the instructions and there are no further questions, we will conduct a short quiz where each of you will complete some tasks on your own. We will walk around, look over your answers, and solve any remaining comprehension problems. The only purpose of the quiz is to ensure that you thoroughly understand the crucial details of the decision-making problem.

Your anonymity and the anonymity of the other participants is guaranteed throughout the entire experiment. You will neither learn about the identity of the other participants, nor will they learn your identity.

B.1 General description

This experiment is about students who are trying to enter a university. The 24 participants in the room are grouped into three groups of eight persons each. These eight participants represent students competing for university seats. You will compete with the same seven participants for the whole experiment. The experiment consists of 20 independent decisions, which represent the students' admission processes. At the end of each round every student will receive at most one seat in one of the universities or will remain unassigned. At the end of the experiment one round will be randomly drawn to determine your payment.

There are eight universities that differ in quality and specialization. Each university has only one seat. Universities admit students based on their final exam grade. Each student has a grade for math and a grade for languages. Universities M1, M2, M3 accept students based on the math grade only. Universities L1, L2, L3 accept based on the languages grade only. Universities H1 and H2 accept based on the average grade of math and languages.

B.2 Instructions for DA

Your payoff depends on a seat of the university you will be assigned to. In order to get a seat at any university you will have to participate in the centralised allocation mechanism. At the beginning of each round you will submit the list of your preferences to the centralised allocation mechanism, and it will use the lists of all the participants in order to determine allocation. All the steps of the allocation described below take place without any further interactions from the students. Thus, the only thing required for the allocation from the students' side is to submit their lists of preferences.

The allocation procedure is implemented in the following way:

1. The mechanism sends applications from all students to the university of their top choice (the one which is stated first in the submitted list sent to the allocation mechanism).

2. Throughout the allocation process, a university can hold no more applications than its number of seats. If a university receives more applications than its capacity then it rejects the students with the lowest relevant score (math grade for M1, M2, M3; language grade for L1, L2, L3, and average grade for H1, H2). The remaining applications are retained.

3. Whenever an applicant is rejected at a university, her application is sent to the next highest university on her submitted list.

4. Whenever a university receives new applications, these applications are considered together with the retained applications for that university. Among the retained and new applications, those with the lowest relevant grades in excess of the number of the slots are rejected, while the remaining applications are retained.

5. The allocation is finalised when no more applications can be rejected. Each participant is assigned a slot at the university that holds his/her application at the end of the process.

B.2.1 Example for DA

Example: In order to understand the mechanism better, let us go through an example together. If you have any questions about any step of the allocation procedure please feel free to ask at any point. There are six students (ID numbers from 1 to 6) on the market, and three universities (University M1, University L1, and University H1) with two seats in each university. Students have the following grades in their exams:

	Student1	Student2	Student3	Student4	Student5	Student6
Math	80	90	60	90	70	40
Language	50	20	80	30	76	82
Average	65	55	70	60	73	61

University M1 ranks students based on the math grade only, University L1 grades students based on the language grade only, and university H1 ranks students based on the average of the two grades. Students submitted the following school rankings in their decision sheets:

Student ID	1	2	3	4	5	6
Top choice	L1	H1	M1	H1	H1	M1
Middle choice	H1	M1	H1	L1	M1	H1
Last choice	M1	L1	L1	M1	L1	L1

This allocation method consists of the following steps:

Step 1.

Students 3 and 6 apply for a seat at M1. University M1 has two seats available for allocation and two applicants, thus students 3 and 6 are retained at University M1.

Student 1 applies to University L1. University L1 has two seats and only one applicant, thus student 1 is retained at University L1.

Students 2, 4, and 5 apply for University H1, but it has only two seats available for allocation, thus one of the applicants must be rejected. University H1 ranks students based on the average grade for math and language: student 2 has an average grade of 55, student 4 has 60, and student

5 has 73. Among the applicants, student 2 has the lowest average grade, thus student 2 is rejected and students 4 and 5 are retained at University H1.

	Retained students in the beginning of the round	Applications of the step	Rejected students
University M1	-	3, 6	-
University L1	-	1	-
University H1	-	2, 4, 5	2

Step 2.

Student 2 is the only student who was rejected in the previous step. She applies to her second choice – University M1. Now University M1 considers student 2 together with the retained students who applied to University M1 in the previous step – students 3 and 6. So the university has three applications for two seats, thus one of the applicants must be rejected. University M1 ranks students based on the math grade: student 2 has a math grade of 90, student 3 has 60, and student 6 has 40. Student 6 has the lowest math grade among the applicants, thus student 6 is rejected from University M1, while students 2 and 3 are retained.

	Retained students in the beginning of the round	Applications of the step	Rejected students
University M1	3, 6	2	6
University L1	1	-	-
University H1	4, 5	-	-

Step 3.

Student 6 applies to University H1. So the university has three applications for two seats, thus one of the applicants must be rejected. University H1 ranks students based on the average grade: student 4 has the average grade of 60, student 5 has 73 and student 6 has 61. Student 4 has the lowest average grade among applicants, thus he is rejected from University H1.

	Retained students in the beginning of the round	Applications of the step	Rejected students
University M1	2, 3	-	-
University L1	1	-	-
University H1	4, 5	6	4

Step 4.

Student 4 applies for University L1. Thus, there are two applications for two seats at University L1. No one is rejected. All current retained allocations are finalised.

	Retained students in the beginning of the round	Applications of the step	Rejected students
University M1	2, 3	-	-
University L1	1	4	-
University H1	5, 6	-	-

Thus, the final allocation looks as follows: University M1 – students 2, 3; University L1 – students 1, 4; University H1– students 5, 6.

B.3 Instructions for IDAM

Your payoff depends on a seat of the university you will be assigned to. In order to get a seat at any university you will have to participate in the centralised allocation mechanism. The allocation procedure is implemented in the following way:

1. All students apply to one of the universities.

a. Throughout the allocation process, a university can hold no more applications than its number of seats. If a university receives more applications than its capacity then it rejects the students with the lowest relevant score (math grade for M1, M2, M3; languages grade for L1, L2, L3, and average grade for H1,H2). The remaining applications are retained.

2. Each student is informed about whether her application was rejected or retained. Moreover, the minimum corresponding grades of the retained students of all universities are publicly

announced. If an applicant is rejected at a university, she can send the application to any other university. If an applicant is retained at a university, she is not active at this step.

3. Whenever a university receives new applications, these applications are considered together with the retained applications for that university. Among the retained and new applications, those with the lowest relevant grades in excess of the number of the slots are rejected, while the remaining applications are retained. All students see the result of the step. Each university publishes the minimum corresponding grade of the retained students. If an applicant is rejected at a university, she can send the application to any other university. If an applicant is retained at any university, she is not active at this step.

4. Step 3 is repeated until the allocation is finalised. The allocation is finalised when no more applications can be rejected. Each participant is assigned a slot at the university that holds his/her application at the end of the process.

B.3.1 Example for IDAM

In order to understand the mechanism better, let us go through an example together. If you have any questions about any step of the allocation procedure please feel free to ask at any point.

There are six students (ID numbers from 1 to 6) on the market, and three universities (University M1, University L1, and University H1) with two seats in each university. Students have the following grades in their exams:

	Student1	Student2	Student3	Student4	Student5	Student6
Math	80	90	60	90	70	40
Language	50	20	80	30	76	82
Average	65	55	70	60	73	61

University M1 ranks students based on the math grade only, University L1 grades students based on the language grade only and university H1 ranks students based on the average of the two grades.

This allocation method consists of the following steps:

Step 1.

Students took the following decisions about their application: Students 3 and 6 apply to M1, student 1 applies to L1, and students 2, 4, and 5 apply to H1.

Students 3 and 6 apply for a seat at M1. University M1 has two seats available for allocation and two applicants, thus students 3 and 6 are retained at University M1.

Student 1 applies to University L1. University L1 has two seats and only one applicant, thus student 1 is retained at University L1.

Students 2, 4, and 5 apply for University H1, but it has only two seats available for allocation, thus one of the applicants must be rejected. University H1 ranks students based on the average grade for math and languages: student 2 has an average grade of 55, student 4 has 60, and student 5 has 73. Among the applicants, student 2 has the lowest average grade, thus student 2 is rejected and students 4 and 5 are retained at University H1.

	Retained students in the beginning of the step	Applications of the step	Rejected applications	Minimum accepted grade
University M1	-	3, 6	-	40
University L1	-	1	-	0
University H1	-	2, 4, 5	2	60

Note, that if a university has a free seat the minimum accepted cutoff grade is zero.

Step 2.

Student 2 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

She decides to apply to University M1.

Now University M1 considers student 2 together with the retained students who applied to University M1 in the previous step – students 3 and 6. So the university has three applications for two slots, thus one of the applicants must be rejected. University M1 ranks students based on the math grade: student 2 has a math grade of 90, student 3 has 60, and student 6 has 40. Student 6 has the lowest grade among the applicants, thus student 6 is rejected from University M1, while students 3 and 2 are retained.

	Retained students in the beginning of the step	Applications of the step	Rejected applications	Minimum accepted grade
University M1	3, 6	2	6	60
University L1	1	-	-	0
University H1	4, 5	-	-	60

Step 3.

Student 6 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

Student 6 decides to apply to university H1.

University H1 considers student 6 together with the retained students – students 4 and 5. So the university has three applications for two seats, thus one of the applicants must be rejected. University H1 ranks students based on the average grade: student 4 has an average grade of 60, student 5 has 73, and student 6 has 61. Student 4 has the lowest average grade among the applicants, thus he is rejected from University H1.

	Retained students in the beginning of the step	Applications of the step	Rejected applications	Minimum accepted grade
University M1	2, 3	-	-	60
University L1	1	-	-	0
University H1	4, 5	6	4	61

Step 4.

Student 4 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

Student 4 decides to apply for University L1.

University H1 considers student 4 together with the retained students – student 1. Thus, there are two applications for two seats at University L1. No one is rejected. All current retained allocations are finalised.

	Retained students in the beginning of the step	Applications of the step	Rejected applications	Minimum accepted grade
University M1	2, 3	-	-	60
University L1	1	4	-	30
University H1	4, 5	6	4	61

Thus the final allocation looks as follows: University M1 – students 2, 3; University L1 – students 1, 4; University H1 – students 5, 6.

B.4 Instructions for IDAM-NC

Your payoff depends on a seat of the university you will be assigned to. In order to get a seat at any university you will have to participate in the centralised allocation mechanism. The allocation procedure is implemented in the following way:

1. All students apply to one of the universities.

a. Throughout the allocation process, a university can hold no more applications than its number of seats. If a university receives more applications than its capacity then it rejects the students with the lowest relevant score (math grade for M1, M2, M3; languages grade for L1, L2, L3, and average grade for H1,H2). The remaining applications are retained.

2. Each student is informed about whether her application was rejected or retained. If an applicant is rejected at a university, she can send the application to any other university. If an applicant is retained at a university, she is not active at this step.

3. Whenever a university receives new applications, these applications are considered together with the retained applications for that university. Among the retained and new applications, those with the lowest relevant grades in excess of the number of the slots are rejected, while the remaining applications are retained. All students see the result of the step. If an applicant is

rejected at a university, she can send the application to any other university. If an applicant is retained at any university, she is not active at this step.

4. Step 3 is repeated until the allocation is finalised. The allocation is finalised when no more applications can be rejected. Each participant is assigned a slot at the university that holds his/her application at the end of the process.

B.4.1 Example for IDAM-NC

In order to understand the mechanism better, let us go through an example together. If you have any questions about any step of the allocation procedure please feel free to ask at any point.

There are six students (ID numbers from 1 to 6) on the market, and three universities (University M1, University L1, and University H1) with two seats in each university. Students have the following grades in their exams:

	Student1	Student2	Student3	Student4	Student5	Student6
Math	80	90	60	90	70	40
Language	50	20	80	30	76	82
Average	65	55	70	60	73	61

University M1 ranks students based on the math grade only, University L1 grades students based on the language grade only and university H1 ranks students based on the average of the two grades.

This allocation method consists of the following steps:

Step 1.

Students took the following decisions about their application: Students 3 and 6 apply to M1, student 1 applies to L1, and students 2, 4, and 5 apply to H1.

Students 3 and 6 apply for a seat at M1. University M1 has two seats available for allocation and two applicants, thus students 3 and 6 are retained at University M1.

Student 1 applies to University L1. University L1 has two seats and only one applicant, thus student 1 is retained at University L1.

Students 2, 4, and 5 apply for University H1, but it has only two seats available for allocation, thus one of the applicants must be rejected. University H1 ranks students based on the average grade for math and language: student 2 has an average grade of 55, student 4 has 60, and student 5 has 73. Among the applicants, student 2 has the lowest average grade, thus student 2 is rejected and students 4 and 5 are retained at University H1.

	Retained students in the beginning of the step	Applications of the step	Rejected applications
University M1	-	3, 6	-
University L1	-	1	-
University H1	-	2, 4, 5	2

Step 2.

Student 2 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

She decides to apply to University M1.

Now University M1 considers student 2 together with the retained students who applied to University M1 in the previous step – students 3 and 6. So the university has three applications for two slots, thus one of the applicants must be rejected. University M1 ranks students based on the math grade: student 2 has a math grade of 90, student 3 has 60, and student 6 has 40. Student 6 has the lowest grade among the applicants, thus student 6 is rejected from University M1, while students 3 and 2 are retained.

	Retained students in the beginning of the round	Applications of the step	Rejected applications
University M1	3, 6	2	6
University L1	1	-	-
University H1	4, 5	-	-

Step 3.

Student 6 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

Student 6 decides to apply to university H1.

University H1 considers student 6 together with the retained students – students 4 and 5. So the university has three applications for two seats, thus one of the applicants must be rejected. University H1 ranks students based on the average grade: student 4 has an average grade of 60, student 5 has 73, and student 6 has 61. Student 4 has the lowest average grade among the applicants, thus he is rejected from University H1.

	Retained students in the beginning of the round	Applications of the step	Rejected applications
University M1	2, 3	-	-
University L1	1	-	-
University H1	4, 5	6	4

Step 4.

Student 4 is the only student who was rejected in the previous step, thus she is the only one who is active at this step.

Student 4 decides to apply for University L1.

University H1 considers student 4 together with the retained students – student 1. Thus, there are two applications for two seats at University L1. No one is rejected. All current retained allocations are finalised.

	Retained students in the beginning of the round	Applications of the step	Rejected applications
University M1	2, 3	-	-
University L1	1	4	-
University H1	4, 5	6	4

Thus, the final allocation looks as follows: University M1 – students 2, 3; University L1 –

students 1, 4; University H1 – students 5, 6.

C Additional results

Table C.1: *Marginal effects of the probit regression of switches to truthful strategy depending on the proportion of straightforward choices in the previous round*

	(1) Switch in DA	(2) Switch in IDAM-NC	(3) Switch in IDAM
Rank of assigned college in previous round	-.02*	-.04***	-.05**
	(.01)	(.01)	(.01)
Prop.of straightf. consec. ch. before last in prev. round	.16	.47***	.29**
	(.12)	(.09)	(.14)
Round	.01**	.02***	.02***
	(.004)	(.004)	(.005)
Increase of grade for the true top choice	.006***	.005***	.01***
	(.001)	(.001)	(.001)
Observations	488	479	349
log(likelihood)	-260.98	-199.36	-194.28

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered on the level of matching groups and are presented in parentheses. Sample restriction: only if non-truthful in previous round, and not assigned to the top submitted choice, as then variable of interest is always 0. Dependent variable is a dummy of switches from non-truthful to truthful strategy. The sample is restricted only to non-truthful strategies in the previous round, and to the cases when the reported top choice was not assigned in the previous round. Increase of grade for the true top choice variable shows the difference between the relevant grade for the true top choice in the previous round and the relevant grade for the true top choice in the current round.

Figure C.1: *Proportions of truthful behavior depending on the rank of submitted choice*