# Redesigning the Israeli Psychology Master's Match

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Prior to 2014, the admission to Master's and PhD programs in psychology in Israel was a mostly decentralized process. In 2013, in response to concerns about the existing procedure,[1] we proposed that a centralized mechanism should be deployed. Our goal was to apply the key lessons learned from decades of applied market design and use a mechanism that has good incentive properties. In particular, we wanted to use a mechanism that is both *stable* and *strategy-proof* for applicants. This paper describes how we successfully centralized this market, and the critical role of recent advances in matching theory.

During the design of the Israeli Psychology Master's Match (IPMM), we met with the faculty of each of the participating programs and asked about the way they choose between applicants. We soon realized that their answers do not fit squarely into "traditional" models of preferences in two-sided matching markets. In particular, departments' choice functions cannot be summarized by a quota and a rank-ordered list (ROL) for each program. Some departments employ affirmative action (through minority quotas). Others aim to equalize the number of advisees each faculty member receives. And finally, some departments are willing to admit a limited number of applicants with different terms (e.g., funding). Since terms can alter preferences between programs, this last feature implies that in order to satisfy the aforementioned desiderata, the applicants' message space must be expressive enough to convey their preferences over program-terms pairs. This market is therefore a special case of the matching-with-contracts model (Hatfield and Milgrom, 2005).

Hatfield and Milgrom study an extension of Gale and Shapley's (1962) college-admissions model, and show that a generalized version of the Deferred Acceptance (DA) algorithm remains strategy-proof (Roth, 1982; Dubins and

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[1]The concerns largely mirror concerns about the decentralized matching process for American clinical psychologists in the 1990s (Roth and Xing, 1997).

Freedman, 1981) and reaches a side-optimal stable matching. These results rely on a substitutability condition, as well as on the "law of aggregate demand" (LoAD).[2]

Hatfield and Kojima (2010) found that stability and strategy-proofness results go through if the substitutes condition is replaced by the weaker unilateral substitutes condition. Hatfield and Kominers (2015) later found an even weaker condition that ensures that the applicant-proposing DA converges to a stable matching and that it is strategy-proof for applicants.[3] However, up until recently, the applicability of these theoretical findings to real-life markets was unclear. Our experience designing the IPMM provides a strong empirical validation to the practical relevance of these recent results in matching theory.

As mentioned above, as part of designing the IPMM, there was a period when every week or so we would speak with another department, listen to their needs, and see how we could accommodate them. Every week we were happy to discover that despite the fact that choice functions did not satisfy the substitutes condition, or even the unilateral substitutes condition, we were somehow able to show that DA would still work with the new requirements. Only after the first year of operation did we learn about the findings of Hatfield and Kominers (2015), which explain why we were successful: all the choice functions used by psychology departments have a substitutable completion that satisfies LoAD.[4] This ensures that DA converges to a stable matching and that it is strategy-proof.

The mechanism that we ended up implementing was indeed a variant of the applicant-proposing DA.[5] Programs report their choice functions using a special interface that offers an expressive enough "bidding language" to report all of the pre-existing choice functions. Our solution is similar to those proposed by Sönmez (2013) and Sönmez and Switzer (2013) for the problem of allocating cadets to military branches. In these two papers, the priorities to be used by the military are unilateral substitutes, but not substitutable. This is sufficient to find strategy-proof alternatives to the mechanisms currently in use. To the best of our knowledge, the IPMM is the first field application of the Gale–Shapley program to a two-sided market with choice functions that violate even the unilateral substitutes condition. Therefore, this is the first documented market whose centralization required the full generality of the matching-with-contracts theory.

[2]See Aygün and Sönmez (2013) for an additional assumption needed for some of the results.

[3]This condition does not guarantee the existence of a side-optimal stable matching.

[4]In fact, during our investigation process one department discovered that its admissions preferences were not well defined. They then decided on a choice function that had a substitutable completion.

[5]Since 2015, couples have been supported through the Ashlagi, Braverman and Hassidim (2014) extension.

# 1 The psychology market prior to 2014

Admission to graduate degrees in psychology in Israel, especially in clinical programs, is highly competitive. The stakes are high: applicants have previously completed their Bachelor's studies in psychology, but this does not grant them the right to practice, and many of them seek a certifying clinical degree, which will keep them on track to a career in a prestigious high-income profession. Each year there are about 1,400 new psychology graduates and fewer than 300 positions in clinical graduate programs. Other, non-clinical, graduate degrees are also available: about 300 applicants join these less demanded programs each year.

The fierce competition induced a process of BA grade inflation and unraveling (i.e., increasingly earlier admissions). In response, all departments agreed to coordinate by instituting a unified screening exam, and by setting an earliest date for commencing the screening of applicants, as well as a protocol to be used for admitting students. The agreed-upon protocol specified three weeks (rounds) during which programs were allowed to contact applicants.

- On the first day of the first week, programs called applicants to notify them of their admission, wait-list status, or rejection. Applicants then had to inform programs within three days about the rejection of offers, or the tentative acceptance of a single offer.

- On the first day of the second week, programs called previously wait-listed applicants and notified them of their admission, rejection, or wait-list status. The applicants again had three days to respond, and were allowed to withdraw their previous acceptance, and to accept (irrevocably) at most one offer.

- On the third and final week, programs called applicants on their wait-list and offered admission. Applicants could no longer withdraw previous acceptances, and could only irrevocably accept incoming offers. Offers in this stage were often "exploding" (had to be accepted or rejected immediately or within a short period of time).

While this process was a major improvement relative to prior market conditions, it was problematic in several respects. The first and most acute problem was that it left much room for strategic behavior. Departments preferred to fill their capacity on the first and second rounds, so as to avoid the need to recruit on the third round. This fear motivated the costly collection of information about applicants' likelihood to accept offers. It also drove departments to offer admission to more students than they wanted to accept, in the expectation that some offers would be rejected. Applicants faced similar strategic problems. For example, since accepting an offer at the second round was irrevocable, applicants who got wait-listed by their preferred program at the beginning of the second round and received an offer from another program they liked less faced the strategic choice between the "riskier" option of waiting and the "safer" acceptance of the less-preferred alternative.

The pre-existing process was also associated with excessive administrative costs, high levels of stress experienced by applicants, and much distrust among departments. Since programs had an incentive to act early, the general sentiment in many departments was that other departments were "cheating" by approaching candidates (explicitly or implicitly) before the prescribed dates, and sometimes "poaching" assigned candidates. Additionally, there was no way to make sure that applicants were following the rules, and not holding more than one offer at any given time.

## 2 Choice functions

In the process of designing the new system, we interviewed the officials in charge of admissions in each of the participating institutions. Our main question was how they choose whom to admit. It is important to underscore that answers were given verbally, and no limitation on "bidding language" was placed. In some cases, we were told that departments would prefer to choose applicants who ranked the program first or at least among the top $k$ alternatives in their ROL. In these cases, we reminded the officials that this was not possible under the current protocol, and explained that our solution would not accommodate this request either. In what follows, we describe the choice functions that were communicated to us (after the clarification above, when necessary).

All programs start by specifying different tracks (if applicable), by providing an ROL, and by setting the quota for the program and for each of the tracks separately.

1. Four departments' programs had responsive choice functions. Admission to each program was determined solely by the provided quota and ROL. There were a few other departments that used such choice functions for a subset of their programs.

2. One program offered a number of seats in the "regular" track and a different number of seats in the "honors" track. Unfilled seats in one track cannot revert to seats in the other.

3. Some departments offered programs with priority seats for (mutually exclusive) categories of applicants.

4. One department offered several programs, some with priority seats and some with a direct PhD option.

5. Two departments had programs that offered a limited number of scholarships to a subset of applicants (with priority to get a scholarship being the same as the regular ranking).

6. Three programs offered a limited number of funded seats and in addition unfunded priority seats to certain groups of applicants.

7. Three programs had a choice function that took into account the academic advisor the applicant would be assigned to. This choice function could be expressed by labeling applicants by their potential advisors and allocating priority seats to each advisor.

8. One department offered degrees in several programs, and in each program four different tracks: unfunded MA and a direct PhD with three different levels of funding. Each study program had a quota, and there was a restriction on the total number of scholarships.

Choice functions (1)–(7) have a substitutable completion that satisfies LoAD. (1) is responsive. (2)–(7) are either slot-specific or task-specific choice functions (these are covered by Hatfield and Kominers, 2015).[6] Function (8) involves simultaneous restrictions that may lead to the inexistence of a stable matching. Luckily, over-demand in this market assured that many quotas were certain to be filled, and this made the relevant department essentially indifferent between this choice function and another that had a substitutable completion that satisfied LoAD.

The following example shows that the full generality of substitutable completability is required to assure strategy-proofness for applicants. Suppose there is one program, and 4 applicants, $i$, $j$, $k$, and $l$, are ranked by desirability, where $i$ is the most desirable and $l$ is the least desirable. There is one PhD scholarship, for which only $i$ is eligible. There is also one MA scholarship, for which both $i$ and $j$ are eligible. The choice function is as follows: optimize the composition of applicants lexicographically subject to the constraints that no applicant is to be accepted with a scholarship she is not eligible for, and no more than one contract is to be signed with each applicant. For simplicity assume that giving less funding is preferred when possible.

This choice function is not unilateral substitutable. To see this, denote $Y = \{i^m\}$, $z = j^m$ and $x = i^p$, where $y^m$ signifies applicant $y$ getting the MA scholarship, and $y^p$ signifies applicant $y$ getting the PhD scholarship, so that $x \notin Ch\,(Y \cup \{x\})$, but $x \in Ch\,(Y \cup \{x, z\})$. Finally, it is easy to verify that this choice function is in fact substitutably completable.

# 3 The IPMM

Every year, since 2014, the matching process begins with an online registration phase.[7] During this phase, departments report all the available contracts for

[6]Choice function (2) could be thought of as a sub-case of (1) from the applicants' perspective. However, since this choice function is an aggregate of the two responsive choice rules, it potentially violates unilateral substitutes. For example, if preferences are given by $\{i^h, j^r\} \succ \{i^h\} \succ \{i^r\} \succ \{j^r\}$, then $j^r \notin Ch(\{i^r, j^r\})$, but $j^r \in Ch(\{i^h, i^r, j^r\})$.

[7]The IPMM uses a website and software created by us especially for this purpose. The (Hebrew) website can be found at `http://www.psychologymatch.org`. The sources for the C++ program that collects departments' choice functions and for the Python script that performs the match can be found on Romm's homepage.

applicants to rank,[8] and applicants provide their national identification number and additional personal information.

After this stage is completed, and after programs conduct interviews, applicants are asked to rank contracts (i.e., program-terms pairs). For example, an applicant could rank a funded position in program $A$ over a position in program $B$ over a non-funded position in program $A$. Applicants submit their ROLs online using a simple drag-and-drop interface. If an applicant submitted an ROL that included a position in some program in which she did not rank all contracts, a pop-up alert appeared. This design feature was meant to mitigate the risk of applicants accidentally ranking only some of the positions offered by a program.[9]

Departments use a designated computer program to specify their choice functions. First, they can label applicants according to categories they choose to create (e.g., belonging to a minority, or being eligible for funding). Then, the department designates priority seats, and sets quotas and nested quotas. Except where priorities are specified, admission is based on a program-specific ROL. This language allows expressing all of the choice functions described above and assures that reported choice functions satisfy substitutable completability and LoAD.

Departments and applicants are informed that their preferences will not be revealed to other departments or applicants (other than in the form of aggregate statistics). The only exception is that the details (but not ROLs) of unmatched applicants are transferred to programs that failed to fill their capacity using the match, or had open positions due to "no-shows."

In order to educate participants about the match, prior to the first year of the match faculty and administrative staff in participating departments attended presentations in which both DA and the fact that it was strategy-proof for the applicants were covered in great detail, in the hope that department members could provide good advice to applicants during (or after) interviews. It was also explained that for the programs, untruthful reporting could, in theory, be beneficial, but that gaining something from such a misrepresentation usually requires extensive knowledge of others' preferences and behavior. Finally, applicants participating in the match were advised on multiple occasions to submit their true preferences, and were told that reporting false preferences could only hurt them as compared to telling the truth.[10]

While only three years of operation have passed, it appears that our efforts have been fruitful. The unraveling process that was previously in place has come to a halt and, as a by-product, trust between colleagues is gradually being restored.[11] In addition, applicants are generally satisfied with the redesign.

[8] Contracts specified a course of study, terminal degree (MA or PhD), and funding terms.

[9] However, see Hassidim, Romm and Shorrer (2016) for a discussion on how, despite this feature, some applicants decided not to rank funded positions.

[10] This advice is communicated in all emails and letters received from the automated matching system or from the departments themselves.

[11] Additionally, when we kicked off the process, one of the department heads said that he would be happy to get a class of the same quality as in the past, without all the fighting and

In a survey that was conducted following the 2015 match, satisfaction with the matching platform received an average score of 8.1/10. By contrast, satisfaction with the entire admissions process got an average score of 4.7/10.

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the wasting of so much time on the process. In retrospect, he claimed to have a better class than in previous years.