Simulating the Mutual Sequential Mate Search Model under Non-homogenous Preferences

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Abstract. This paper extends the Todd and Miller's (1999) mutual sequential mate search model with homogenous preferences to the case of non-homogenous preferences. Our simulations show that the size of heterogeneity in the preferences affects the performance rankings -as well as the absolute success levels- of the mate search heuristics in the model with respect to both mating likelihood and mating stability.

Key words: Mate Choice, Mate Search, Simple Heuristics, Agent-Based Simulation, Correlated Preferences

1 Introduction

A strand of literature in the cognitive psychology studies the human mate choice as a mutual-decision problem under uncertainty. A pioneering work of this literature, by Todd and Miller (1999), offers a boundedly rational solution to this problem with the help of simple satisficing heuristics. These heuristics -so called Mate Value-5, Take the Next Best, Adjust Up/Down, Adjust Relative, and Adjust Relative/2- are aspiration-setting mechanisms which people are assumed to use as mate search strategies. While Mate Value-5 unrealisticly assumes that people know their self mate values, the other four heuristics assume that people have initially no knowledge -and later incompletely learn- about their own mate values. The learning process is assumed to take place in an adolescence or dating phase -prior to the mating phase- where people, who aim to approximate their unknown mate values by their aspiration levels, adjust their initial aspiration levels based on their observations about the mate values of their dates as well as on the information they exchange with their dates as to their desirability. Then, in the mating phase people randomly interact with potential mates and decide whom to make a proposal.

Todd and Miller (1999) investigate the performances of their mate search heuristics by conducting Monte Carlo simulations of their mate choice model under each heuristic. In these simulations, they focus on two main success measures: (i) the mating likelihood measured by the number of mated pairs in the population, and (ii) the mating stability measured by the (inverse of) mean within-pair difference in mate value. Their findings show that Mate Value-5, which assumes that the pre-mating aspiration level of each agent is lower than his/her self mate value by 5 points, is the best heuristic both in paring up a very big proportion of the population and in pairing up agents with almost identical mate values. On the other hand, the second best heuristic turns out to be Adjust Relative/2, according to which an agent raises (reduces) his/her aspiration level by an individual-specific and time-varying parameter, if this agent and his/her date find each other desirable (non-desirable).

Some recent works extend -or check the robustness of- the human mate choice model of Todd and Miller (1999) in different directions. For example, Shiba (2013) extends the symmetric two-sided sequential mate search model of Todd and Miller (1999) to an asymmetric case where the two sides of the mating population use different mate search heuristics, while Saglam (2014) studies whether any mate search heuristic of Todd and Miller (1999) can be obtained as a Nash (1950) equilibrium of a strategic-form game where each agent non-cooperatively decides on the heuristic he/she will use in the adolescence phase. More recently, Saglam (2017) studies whether one can find -for the human mate choice model- a new mate search heuristic that could be in terms of mating likelihood as good as Mate Value-5, the most successful, yet also informationally unrealistic, heuristic of Todd and Miller (1999).

Like in Shiba (2013) and Saglam (2014), we aim to study the robustness of Todd and Miller's (1999) simulation results with respect to a variation in the human mate choice model. This variation relaxes in their model the assumption of completely homogenous mate preferences, which we find unrealistic and very restrictive. In fact, this point was already acknowledged by Todd and Miller (1999, pp. 307) who stated that:

> "We have given everyone in the population precisely the same impression of all the members of the opposite sex (all females rank all the males the same way, and vice versa), but this is not realistic either: There will typically be some degree of agreement about who is a good catch and who is not, but there will also be a large amount of idiosyncrasy in individual mate preferences."

In line with the above remarks, we study in this paper how Todd and Miller's (1999) simulation results would change when the preferences of agents are partially or completely idiosyncratic (i.e., heterogenous). Some questions we hope to answer in light of our simulations are whether the reported outstanding performance of Mate Value-5 arises because of Todd and Miller's homogeneity assumption over preferences and whether a sufficient amount of heterogeneity in preferences can significantly improve the relative or absolute performances of other mate search heuristics.

The rest of our paper is organized as follows: In Section 2 we present the model of Todd and Miller (1999), without restricting agents' preferences over potential mates. Section 3 contains our simulation results. In Section 3.1 we consider the case of completely homogenous preferences studied by Todd and Miller (1999) and replicate their simulation results. In Section 3.2 we consider the case of completely heterogenous preferences, while in Section 3.3 we elaborate the most general case of correlated preferences. Finally, we conclude in Section 4.

2 Model

We will here present the mutual sequential mate search model of Todd and Miller (1999) without putting any restriction on agents' preferences over potential mates. This model considers a finite and equal number of males and females each of whom searches for a mate from opposite sex. This search consists of two consecutive phases: the adolescence (dating and learning) phase and the mating phase. In the adolescence phase each agent sequentially and randomly interacts with a fixed number of dates of opposite sex. At each interaction, each agent observes the mate value of his/her date, and if this value is equal to or above (below) his/her own aspiration level, then the agent informs the date that he/she is found desirable (non-desirable). Symmetrically, each agent is informed by his/her date whether he/she is found desirable. Using this knowledge, each agent adjusts his/her aspiration level after each dating according to some heuristic commonly used by the whole population.

After the adolescence phase, agents enter the mating phase where males and females are randomly paired. Each agent makes a proposal to his/her partner, if the mate value of his/her partner is not below his/her aspiration level finalized at the end of the adolescence phase. If agents in a random pair propose to each other, then they are mated and removed from the mating pool. Otherwise, they both become available for a possible next pairing. The mating phase ends when the mating pool contains no member or each member inside it has unsuccessfully been paired with all potential mates.

There are five aspiration-setting heuristics introduced by Todd and Miller (1991): Take the Next Best, Mate Value-5, Adjust Up/Down, Adjust Relative, and Adjust Relative/2. Take the Next Best assumes an initial aspiration level of zero and then sets the aspiration level of any agent in any dating stage to the mate value of his/her current date if this date is found desirable, and makes no adjustment otherwise. On the other hand, Mate Value-5 always sets the aspiration level of each agent to a constant that is lower than his/her own mate value by 5 points. As already noted by Todd and Miller (1991), this search rule is not plausible as it assumes that each agent knows his/her own mate value. The remaining three rules, which all assume that the initial aspiration level is equal to the mean mate value in the mating population, can make adjustments in both upwards and downwards directions, whenever required. Under Adjust Up/Down, each agent adjusts up his/her aspiration level in any stage by a constant if he/she is found desirable by his/her current date, and otherwise adjusts down his/her aspiration by the same constant. This constant of adjustment is equal to the mean mate value in the population divided by the number of dates interacted in the adolescence phase plus one. Under Adjust Relative, each agent adjusts up (down) his/her aspiration level by the constant used in Adjust Up/Down if this agent and his/her date find each desirable (non-desirable). Otherwise, the agent makes no adjustment. Finally, Adjust Relative/2 differs from Adjust Relative in that the size of adjustment is not constant and for each agent it is equal -in any stage- to the half of the difference between the previous aspiration level of this agent and the mate value of his/her current date.

3 Simulations

Below, we will simulate the mate choice model described above under different assumptions about agents' preferences over potential mates. For all simulations, we consider a mating population involving 100 males and 100 females, as in Todd and Miller (1999). [We conduct our simulations with the help of GAUSS Software Version 3.2.34 (Aptech Systems, 1998). The source code of the simulation program and the resulting data are available from the author upon request.]

3.1 Completely Homogenous Preferences

As in Todd and Miller (1999), we assume here that each agent's mate value can be correctly observed by any potential mate interacted in any phase of mate search. Thus, males are assumed to have homogenous preferences over females, and vice versa. Accordingly, we randomly set, as in Todd and Miller (1999), the mate value of each agent using a uniform distribution over $[0, 100]$. Also, we vary the length of adolescence (the number of dates) from 1 to 90, and conduct 100 Monte Carlo simulations for each adolescence length.

We first calculate for each heuristic the likelihood of mating, as represented by the number of mated pairs formed in 100 potential pairs. Figure 1 shows that when agents have homogenous preferences Mate Value-5 is outstandingly superior to the other heuristics. As already observed by Todd and Miller (1999) this is due to the humbleness of Mate Value-5. Under this heuristic, people set their aspiration levels always (five points) below their own mate values and are ready to match with candidates with a mate value above their modest thresholds. However, this superior heuristic is also very problematic: it is based upon an unrealistic assumption that requires each agent to completely know his/her own mate value before the beginning of the adolescence phase of the mating process. So, Mate Value-5 should be left out of consideration, one needs to have a closer look at the performances of the remaining four heuristics. Of these, Take the Next Best leads to lower mating likelihood than every other heuristic unless the adolescence length is very short, whereas the relative performances of the other three heuristics with respect to each other depend on the adolescence length. Of these, Adjust Relative/2 performs slightly better than both Adjust Up/Down and Adjust Relative for short to medium adolescence lengths, while the opposite is true when the adolescence length is large.

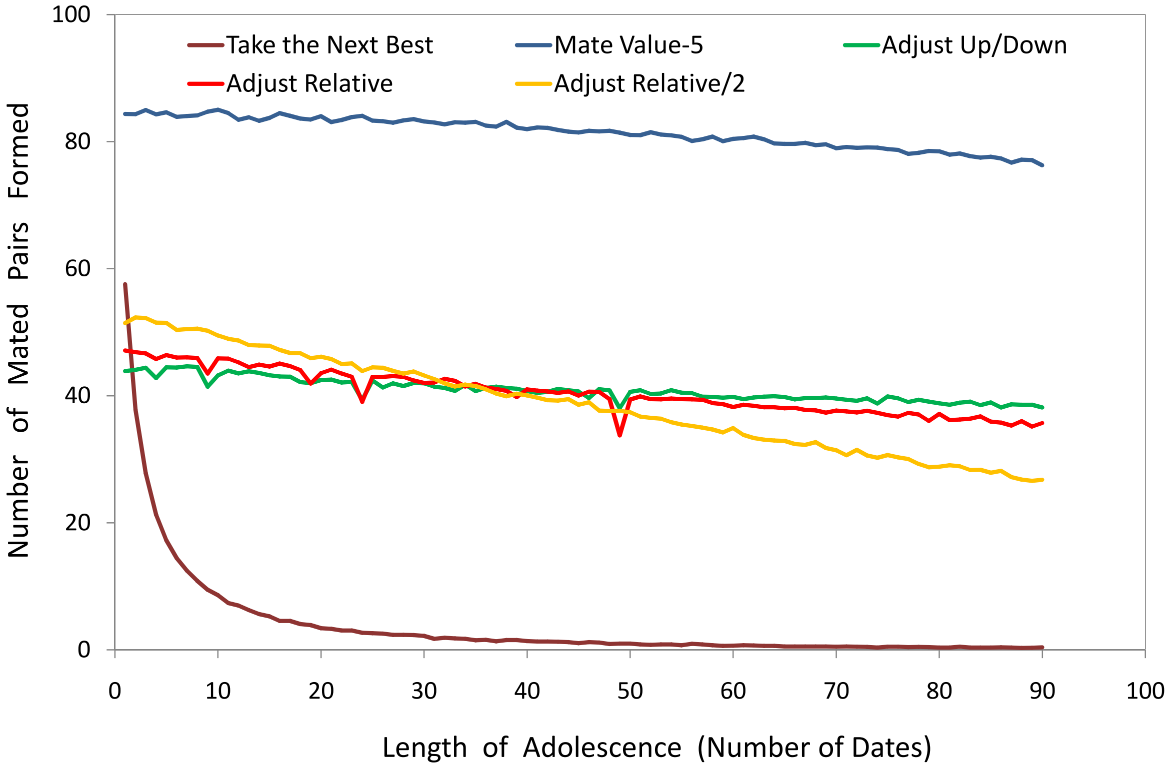


Figure 1.

The second measure of success considered by Todd and Miller (1991) is the mean within-pair difference in mate value, which -they argue- might measure the stability of mating, since higher likelihoods of divorce could be expected under higher scores of this measure. Below, we illustrate the replicated performances of Todd and Miller's (1991) heuristics with respect to this second measure.

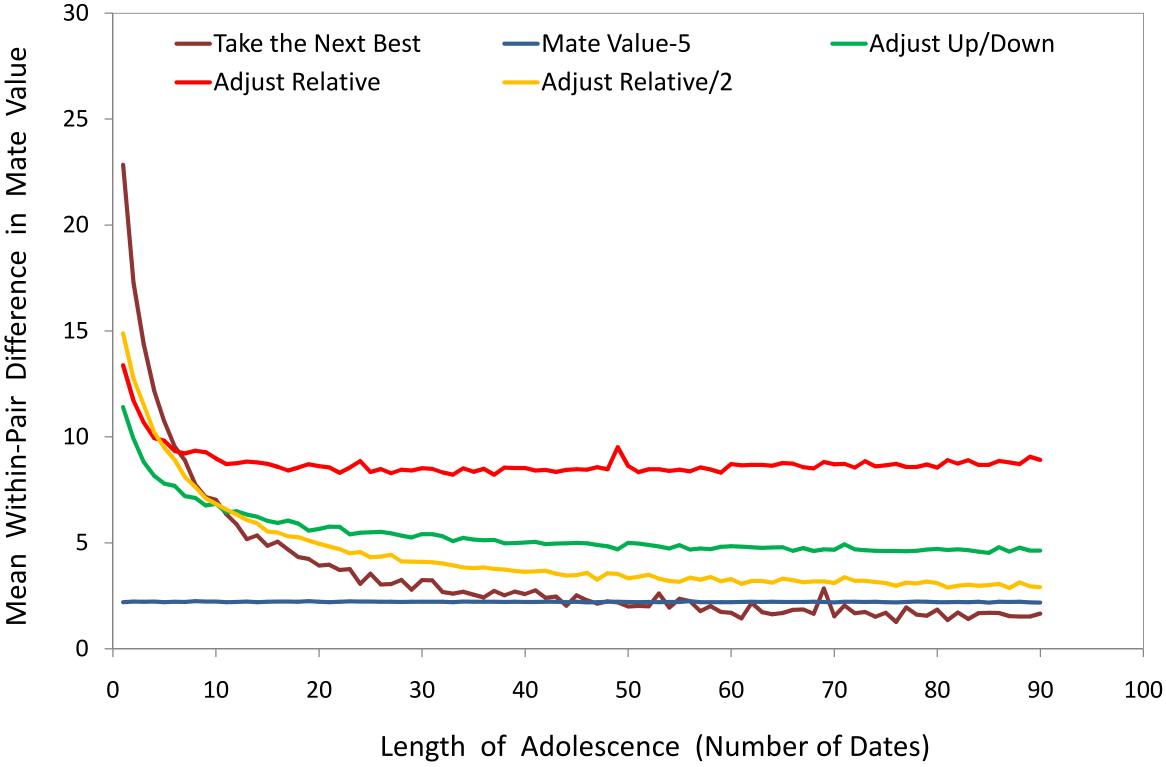


Figure 2.

Figure 2 shows that Mate Value-5 is the most successful heuristic with respect to the measure of mating stability, as well. Take the Next Best, which turns out to be the worst heuristic for small adolescence lengths, becomes as good as Mate Value-5 for medium to large adolescence lengths. Of the other three heuristics, Adjust Relative/2 almost always dominates Adjust Up/Down, while Adjust Up/Down always dominates Adjust Relative. The findings in Figure 1 and Figure 2 together show that if one leaves the unrealistic rule of Mate Value-5 out of consideration, the best performing mate search rule seems to be Adjust Relative/2, closely followed by Adjust Up/Down.

3.2 Completely Heterogenous Preferences

Now, we will reverse the assumption of Todd and Miller (1999) to consider another unrealistic case where the preferences of agents over potential mates are completely idiosyncratic or heterogenous. In accordance with this assumption, for every agent x and for every other agent y from the opposite sex, we randomly set the observation of y about the mate value of x using a uniform distribution over $[0, 100]$. Similarly, to be used by the heuristic of Mate Value-5 and by the measure of mating stability, we randomly set the observation of every agent x about his/her own mate value using a uniform distribution over $[0, 100]$. Also, we vary the length of adolescence (the number of dates) from 1 to 90, and conduct 100 Monte Carlo simulations for each adolescence length.

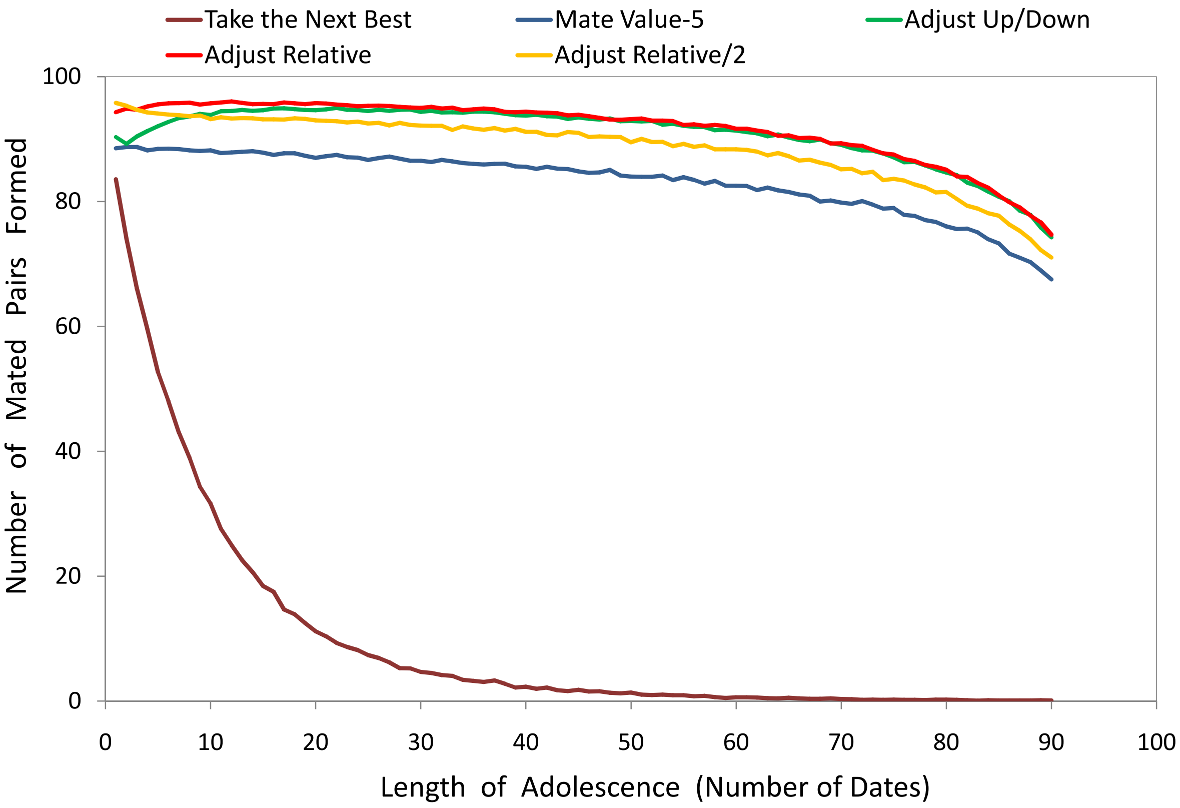


Figure 3.

In Figure 3 we illustrate the mating likelihood of the studied mate search heuristics under completely heterogenous preferences. We find that all heuristics, except for Take the Next Best, always dominate Mate Value-5 with outstandingly high scores of mating likelihood that are fairly stable around %90 for most adolescence lengths. Moreover, we observe that the performances of Adjust Up/Down, Adjust Relative, and Adjust Relative/2 are very close. Nevertheless, among these three heuristics Adjust Relative seems to be slightly superior to the others, by yielding the highest scores at almost all adolescence lengths. On the other hand, Adjust Up/Down, which is as good as Adjust Relative at a large portion of the simulation range, is slightly inferior to both Adjust Relative and Adjust Relative/2 at very small adolescence lengths.

In Figure 4 we report the mean within-pair difference in mate value generated by the five heuristics of Todd and Miller's (1999) under completely heterogenous preferences.

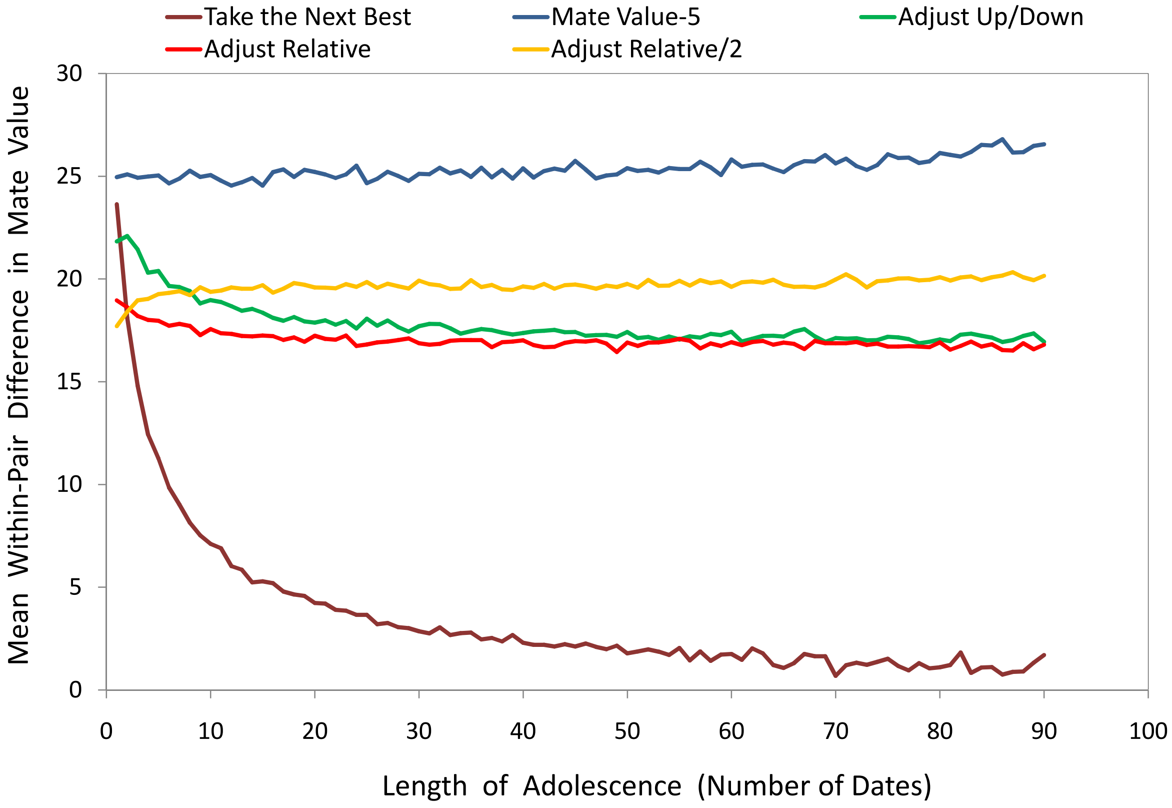


Figure 4.

It is evident from Figures 2 and 4 that for all heuristics, except for Take the Next Best, the mean within-pair difference in mate value is higher (or equivalently the mating stability is lower) under completely heterogenous preferences than under completely homogenous preferences. Also, one can observe that the stability rankings of the five heuristics also change with the type of preferences. Take the Next Best, the second-best heuristic under completely homogenous preferences becomes the first-best heuristic under completely heterogenous preferences with respect to the induced mating stability. The relative rankings of the other four heuristics also change in the two cases. Whereas under completely homogenous preferences these heuristics are ranked from the most stable to the least stable in the order of Mate Value-5, Adjust Relative/2, Adjust Up/Down, and Adjust Relative, this order becomes completely reversed under completely heterogenous preferences.

If Figures 3 and 4 are inspected together, it can be seen that there is no heuristic which is dominant to the others with respect to both mating likelihood and mating stability. For example, Take the Next Best, which is outstandingly superior to the other four heuristics in terms of mating stability, is at the same time the worst performing heuristic with respect to mating likelihood. On the other hand, if Take the Next Best is ruled out because of its inability to generate an ‘acceptable’ level of mating likelihood, one can select Adjust Relative as the most successful heuristic which yields better scores with respect to both mating likelihood and mating stability than Mate Value-5, Adjust Up/Down, and Adjust Relative/2. However, one should also acknowledge the fact that the performance of Adjust Up/Down is only slightly worse than Adjust Relative with respect to both mating likelihood and mating stability.

Finally comparing the findings in this section and in Section 3.1, we observe that under completely homogenous preferences, Adjust Relative/2 becomes the most successful heuristic if one leaves the unrealistic heuristic of Mate Value-5 out of consideration, whereas under completely heterogenous preferences the most successful heuristic is Adjust Relative very closely followed by Adjust Up/Down, both of which are superior to even Mate Value-5 with respect to both mating likelihood and mating stability at all adolescence lengths.

3.3 Correlated Preferences

Now, we will consider the general -and also the only realistic- situation, namely the case of correlated preferences, which will involve the previous cases of completely homogenous and completely heterogenous preferences as two extreme situations. Basically, here we assume that different agents have in general partially correlated and partially idiosyncratic observations about the mate value of the same potential mate. To state this assumption more formally, we will write the preferences in the perfectly correlated (homogenous) and perfectly idiosyncratic (heterogenous) cases separately, and then get a weighted average of them for an arbitrary weight.

So, let us first pick for each agent x in the mating population a randomly drawn value from a uniform distribution of values in $[0, 100]$. We denote this value by $comval(x)$ and call it the mate value of agent x commonly observed by all potential mates in the case of perfectly correlated preferences. (In addition, independently from the size of correlation in the preferences, the heuristic of Mate Value-5 and the measure of mating stability will use $comval(x)$ as the self mate value of agent x.)

Next, let us pick any agent x and any other agent y from the opposite sex, and let us set the observation of y about the mate value of x to a randomly drawn value from a uniform distribution of values in $[0, 100]$. We denote this value by $prival(x, y)$ and call it the mate value of agent x privately observed by agent y in the case of perfectly idiosyncratic preferences.

Finally, we pick any real number w in $[0, 1]$ and define for each agent x and for each potential mate y the value

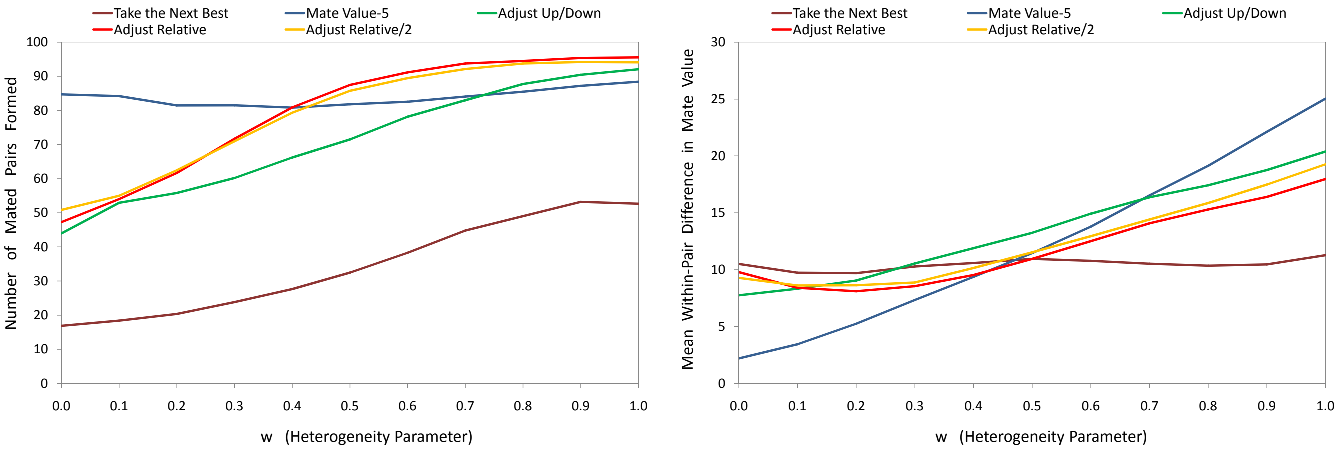
$$corval(x, y) = w\, prival(x, y) + (1 - w)\, comval(x)$$

as the mate value of agent x privately observed by mate y in the case of correlated preferences under the heterogeneity (idiosyncrasy) parameter w. Clearly, the correlation between agents' preferences decreases with an increase in the parameter w, while the extreme cases $w = 0$ and $w = 1$ correspond to the cases of completely homogenous (common) and completely heterogenous (private) preferences respectively.

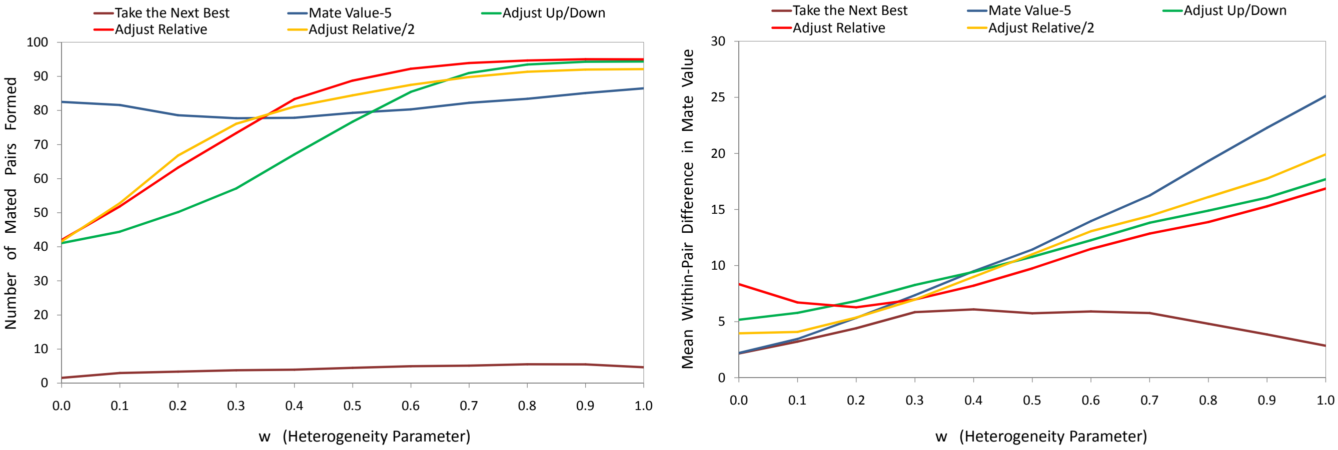
Since our aim here is to study the effect of heterogeneity parameter w on the performances of different heuristics, we conduct our simulations with a few selected values for the adolescence length due to space limitations of our paper. Formally, we vary the adolescence length inside the set $\{5, 30, 60\}$. On the other hand, for each adolescence length we vary the heterogeneity parameter w with increments of 0.1 in its unit simplex and for each value of w we conduct 100 Monte Carlo simulations.

Our results illustrated in Figure 5 show that when preferences of agents are less correlated (i.e., more heterogenous), the number of mated pairs formed (i.e., the mating likelihood) is generally higher for Adjust Up/Down, Adjust Relative, and Adjust Relative/2. The mating likelihood scores generated by Mate Value-5 slightly change (in an interval between approximately %70 and %85) with respect to the heterogeneity parameter. On the other hand, the scores of Take the Next Best are quite small and also mildly increasing in the heterogeneity parameter if the adolescence length is small, while they are extremely small and almost constant otherwise. Our results also show that Take the Next Best is always the inferior search rule independent of the size of heterogeneity in preferences. Interestingly, Mate Value-5 dominates all other rules when the size of heterogeneity in preferences is small and otherwise it is dominated by all other rules, except for Take the Next Best. One can also see that when the size of heterogeneity in preferences is not small, the superior rule with respect to mating likelihood is Adjust Relative, which is closely followed by Adjust Relative/2 (Adjust Up/Down) when the adolescence length is small (medium to large).

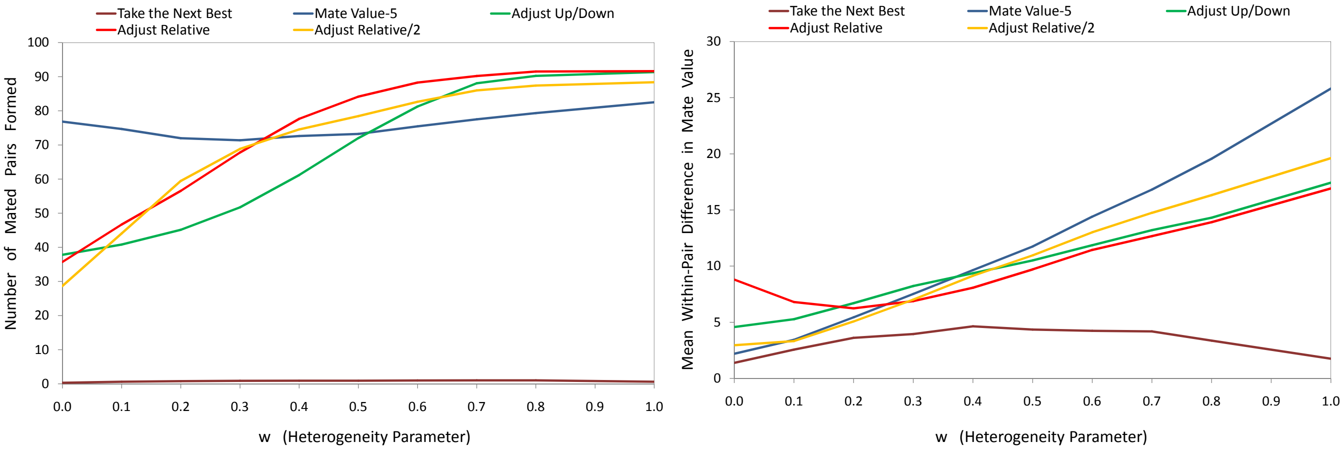
Figure 5 also shows that when the adolescence length is not very small, Take the Next Best yields outstandingly more stable matings than all other heuristics irrespective of the size of heterogeneity in preferences. In fact, even when the adolescence length is very small (i.e., when it is equal to 5), Take the Next Best dominates the other heuristics in terms of mating stability if preferences are sufficiently heterogenous (i.e., w is not less than 0.5). On the other hand, when the adolescence length is very small and the preferences are sufficiently correlated/homogenous (i.e., w is less than 0.5), Mate Value-5 becomes the superior heuristic. One can also see in Figure 5 that irrespective of the adolescence length the second-best heuristic with respect to the stability measure is Adjust Relative when the size of heterogeneity in preferences is medium to large. Moreover, irrespective of the adolescence length, any amount of heterogeneity in preferences worsens the stability performances of Mate Value-5



(a) Length of Adolescence=5



(b) Length of Adolescence=30



(c) Length of Adolescence=60

Figure 5

and Adjust Up/Down, while (only) small amounts of heterogeneity can improve the respective performances of Adjust Relative and Adjust Relative/2.

4 Conclusions

In this paper, we have extended Todd and Miller's (1999) mate choice model with completely homogenous preferences to the case of non-homogenous (partially or completely idiosyncratic) preferences. In the case of homogenous preferences, it is known that among the five mate search heuristics of Todd and Miller (1999) the most successful heuristic is Adjust Relative/2 if one leaves the unrealistic heuristic of Mate Value-5 out of comparison. Our simulations in this paper have revealed that in the case of sufficiently heterogenous preferences the most successful heuristic becomes Adjust Relative, closely followed by Adjust Up/Down.

We have also found that at all adolescence lengths and under even mild levels of heterogeneity in preferences, the three heuristics, Adjust Relative, Adjust Up-Down, and Adjust Relative 2, all become -in terms of both mating likelihood and mating stability- superior to Mate Value-5, the most successful heuristic in the case of completely homogenous preferences. We should recall that these three heuristics adjust aspirations symmetrically in the upwards and downwards directions and therefore they always yield -at the end of the adolescence phase- an average aspiration that is very close to the average mate value in the population. On the other hand, the average aspiration is always 5 points below the average mate value under Mate Value-5, while it can be very close to the highest mate value under Take the Next Best unless the adolescence length is very small. These observations indicate that mate search heuristics that are more egalitarian in setting aspirations become more successful under sufficiently heterogenous preferences with respect to both mating likelihood and mating stability.

Our simulations have also showed that for all heuristics, except for Mate Value-5 and Take the Next Best, the size of heterogeneity in preferences positively affects the mating likelihood irrespective of the adolescence length. This result makes sense since an increase in the size of heterogeneity in preferences reduces the likelihood of competition by different agents over any particular potential mate. On the other hand, for all heuristics, except for Take the Next Best, the size of heterogeneity in preferences, beyond a certain level, has a negative effect on the induced mating stability (i.e., it increases the mean within-pair difference in mate value), indicating that people non-assortatively find their mates under these mate search heuristics. As a matter of fact, only at very low levels of heterogeneity and only for the heuristics of Adjust Relative and Adjust Relative/2, one can observe that the mating stability can be higher under non-homogenous preferences than under completely homogenous preferences.

All in all, out study shows that the specification of the human mate choice model on people's preferences over the potential mates may have significant effects on the relative, as well as the absolute, performances of the mate search heuristics.

References

APTECH Systems. (1998) GAUSS version 3.2.34. Maple Valley, WA: Aptech Systems, Inc.

Nash, J. (1950) Equilibrium points in n-person games. *Proceedings of the National Academy of Sciences*, 36, 48-49.

Saglam, I., (2014) Simple heuristics as equilibrium strategies in mutual sequential mate search. *Journal of Artificial Societies and Social Simulation*, 17 (1), 12.

Saglam, I., (2017) A New Heuristic in Mutual Sequential Mate Search (May 28, 2017). Available at SSRN: https://ssrn.com/abstract=2976502 or http://dx.doi.org/10.2139/ssrn.2976502.

Shiba, N., (2013) Analysis of asymmetric two-sided matching: Agent-based simulation with theorem-proof approach. *Journal of Artificial Societies and Social Simulation*, 16 (3), 11.

Todd, P. M. & Miller, G. F. (1999) From pride and prejudice to persuasion: Satisficing in mate search. In G. Gigerenzer, P. M. Todd & the ABC Research Group (Eds.), *Simple Heuristics That Make Us Smart*(pp. 287-308). New York: Oxford University Press.