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A Rational Reconstruction of Expert Judgments in Organ Allocation

A Conjoint Measurement Approach.

Abstract: The Eurotransplant Kidney Allocation System (ETKAS) emerged from the XCOMB model by Wujciak and Opelz (1993a,b), who applied computer simulation studies to create an allocation algorithm. The present study investigated how experts would allocate a donated organ to patients on the waiting list with respect to the five allocation factors proposed in the ETKAS (number of mismatches, mismatch probability, waiting time, distance, international exchange balance). The experts' evaluations were compared to the ETKAS points as well as to factor weights established in mandatory allocation guidelines which are based on the German law for organ allocation (Transplantationsgesetz). The investigation was carried out using a conjoint analysis. Overall, the results indicate a fairly high degree of agreement between the experts' opinions and the existing allocation system ETKAS and even more so for the allocation guidelines, in particular, with respect to the factors *Mismatches, Mismatch probability*, and *Waiting time.*

1. Introduction

The new Eurotransplant Kidney Allocation System (ETKAS) was installed in 1996. It provides a point-score system that takes into account the number of HLA mismatches, the chance of a good HLA match (mismatch probability), waiting time, the distance between donor and transplant program, and the international exchange balance. ETKAS emerged from the XCOMB model by Wujciak and Opelz (1993a,b), who applied computer simulation studies including these five factors to create an allocation algorithm. The purpose of the present study was to elicit the experts' judgment on how they would allocate a donated organ to patients on the waiting list with respect to the five allocation factors. This is the first time that experts' evaluations have been compared to the existing allocation point scores of ETKAS. In the following the material for eliciting the experts' evaluations is presented. The method—conjoint analysis—to analyze the evaluations is characterized as well. The results are described and compared to the ETKAS system and to guidelines based on the German law for organ allocation (Transplantationsgesetz).

2. Method

In practice, once a donor kidney is obtained, the ETKAS algorithm selects and sorts the eligible transplant recipients. In the present study hypothetical patients were constructed with respect to a given hypothetical donor kidney and experts were asked to sort or rank order the hypothetical patients according to his or her evaluation of the recipient's priority.

The hypothetical patients are described according to the five factors of XCOMB or ETKAS, respectively. The point system of ETKAS published in De Meester et al. (1998), which lists the factors, the levels of each factor, and the respective points, is shown in Table 1.

HLA Mismatch	0	1	2	3	4	5	6
Points	400	333	266	200	133	66	0
Mismatch probability	Low			⟶			High
Points	100			⟶			0
Waiting time	Highest			⟶			Lowest
Points	200			⟶			0
Distance	Local	Regional		National			International
Points	300[a]	208		104			0
Import/export balance	Lowest			⟶			Highest
Points	200			⟶			0

Table 1: The five factors and their levels plus the corresponding points of XCOMB or ETKAS, respectively as published in De Meester et al. (1998).
[a] This value was changed from 260 to 300 points six months after implementation.

In this study only a subset of the levels of each factor were considered. In particular, for factor ***HLA mismatches*** four levels were taken into account: 0 MM, 1 MM, 3 MM, 5 MM. The factor ***Mismatch probability*** was renamed ***Matchability*** and included three factors: low, medium, high. This was done because it seemed to be easier to communicate probabilities in terms of verbal labels (cf., Wallsten & Budescu, 1995) than to provide the exact formula for determining the mismatch probability.[1] For factor ***Waiting time*** four levels were considered: 6 years, 4 years, 2 years, 0.5 years. The factor ***Distance*** was labeled ***Distance of kidney transportation*** and included four levels: no, short, medium, far. The factor ***National net import/export balance*** was renamed ***Donation willingness of the patient's country***, and three levels were included: high, medium, low. Similar to the above, this was done for reasons of better communication.[2] An example

[1] Mismatch probability is defined in terms of the probability of zero or one mismatch among 1000 random donors. With $Pr(MM = 0)$ and $Pr(MM = 1)$ as the probability of zero and one mismatch, respectively, the mismatch probability is $(1 - Pr(MM = 0) - Pr(MM = 1))^{1000}$.

[2] The national net import/export balance is determined on a one-year-base. Upon the implementation of the ETKAS, the previous 365 days (before March 11, 1996) were used as the period for calculating the starting values of the national net kidney import/export balance.

of two hypothetical patients is shown in Table 2. The set of all hypothetical patients is found in Appendix B.

Patient # 28		
Number of mismatches:	0 MM	
Matchability:	high	
Waiting time:	4 years	
Distance of kidney transportation:	medium	
Donation willingness of patient's country:	high	Rank:
Patient # 14		
Number of mismatches:	1 MM	
Matchability:	low	
Waiting time:	6 years	
Distance of kidney transportation:	no	
Donation willingness of patient's county:	medium	Rank:

Table 2: Characteristics of two hypothetical patients with respect to a hypothetical donor kidney. Altogether 32 such examples of patients were constructed, printed on cards, and rank ordered by experts according to receiver priority.

Altogether, 576 ($4 \times 3 \times 4 \times 4 \times 3$) possible hypothetical recipients can be constructed. It would clearly be a task too demanding and time-consuming to rank order 576 patients completely. For this reason, a reduced design, more specifically an orthogonal design[3] was chosen, requiring a minimum of 25 hypothetical recipients for rank ordering. Seven additional hypothetical patients were included to improve the estimation.

Each of the 32 descriptions of hypothetical recipients were printed on cards. Together with a description of the task and the factors (Appendix A), these cards were sent to 52 experts of various transplantation centers throughout Germany. 33 experts responded, anonymously. The experts' rank orders (Appendix B) were evaluated by a conjoint analysis procedure.

Points are given according to the net balance, i.e., low points for a positive net balance, high points for a negative net balance.

[3] A reduced design is a subset of all possible combinations (complete design). An orthogonal design is one in which the levels of different factors across profiles (here patients) are uncorrelated, i.e., there are no interactions. For example, the evaluation of the level *6 years* of the factor *waiting time* does not depend on any level of the factor *number of mismatches* or any level of the factor *distance of kidney transportation.* Such a design ensures that an estimate of one factor is unaffected by the estimate of other factors. The influence of a single factor is termed main effect.

3. Digression: Conjoint Measurement and Conjoint Analysis

In 1964 Luce and Tukey published a paper on *Simultaneous conjoint measurement: A new type of fundamental measurement* which has been considered as the origin of conjoint analysis. Conjoint measurement emerged from an attempt to apply extensive measurement to preference judgments. A theory of extensive measurement goes back to Hölder (1901) who developed the first axiomatic analysis of extensive attributes such as length and mass. It is a set of assumptions (axioms), formulated as an ordering $\succeq$ of objects (weights, rods) with respect to some property (heavier, longer) and a concatenation $\circ$ between the objects that allows for constructing a scale ϕ satisfying $a \succeq b$ if and only if (iff) $\phi(a) \geq \phi(b)$ and $\phi(a \circ b) = \phi(a) + \phi(b)$. The theory of conjoint measurement was developed to create a measurement scale for compound or conjoint objects which preserve their observed order with respect to properties such as 'preferred to' or "better". An additive conjoint structure with more than two components or factors is defined as follows (in the present study we have $N = \{1, 2, 3, 4, 5\}$ factors, in general $N = \{1, 2, \ldots, n\}$) :

DEFINITION: Suppose that A_i, $i \in N, n \geq 3$, are nonempty sets and that $\succeq$ is a binary relation on $X_{i=1}^{n} A_i$.. The structure $\langle A_1, \ldots, A_n, \succeq \rangle$ is an *n-component, additive conjoint structure* iff $\succeq$ satisfies the following five axioms: (1) Weak ordering; (2) independence; (3) restricted solvability; (4) Archimedean property, that is, every strictly bounded standard sequence is finite; (5) at least three components are essential.

The first two axioms are empirically testable. A *weak order* requires that for all elements $a, b, c \in A_i, (i = 1, \ldots, n)$, the following is satisfied: a) Either $a \succeq b$ or $b \succeq a$ (completeness); and b) If $a \succeq b$ and $b \succeq c$, then $a \succeq c$ (transitivity). For example, let $A_1 = \{0, 1, 2, 3, 4, 5\}$ be the number of mismatches, then a) ordering these elements is possible. b) If 0 MM is considered better than 1 MM and 1 MM better than 2 MM, then 0 MM is considered better than 2MM which is intuitively reasonable to assume.

A relation $\succeq$ on $X_{i=1}^{n} A_i$ is *independent* iff, for every subset M of N ($M \subset N$), the ordering $\succeq_M$ induced by $\succeq$ on $X_{i \in M} A_i$ for fixed choices $a_i in A_i$, $i \in N - M$, is unaffected by those choices. For example, let A_1 be as before, A_2 be the matchability (high, medium, low), and A_3 be the waiting time (in years), $A_2 = \{0.5, 1, 2, 3, 4, 5, 6\}$. If (2 MM, low, 2 years) is preferred to (3 MM, low, 2 years), then (2 MM, high, 2 years) is preferred to (3 MM, high, 2 years). Or if (1 MM, 3 years) is preferred to (3 MM, 3 years), then (1 MM, 5 years) is preferred to (3 MM, 5 years), independent of the common factor. This applies for all subsets of N and all levels of factors.

If these axioms are not violated, then the basic representation theorem guarantees that an order structure (for example, a preference order of experts) can be mapped onto a numerical scale (interval scale) that goes beyond simple ordering.

THEOREM Suppose $\langle A_1, \ldots, A_n, \succeq \rangle$, $n \geq 3$, is an n-component, additive conjoint structure. Then there exist functions ϕ_i from A_i, $i = 1, \ldots, n$ into the real numbers such that, for all $a_i, b_i \in A_i$

$$a_1 a_2 \cdots a_n \succeq b_1 b_2 \cdots b_n \quad \textit{iff} \quad \sum_{i=1}^{n} \phi_i(a_i) \geq \sum_{i=1}^{n} \phi_i(b_i).$$

If $\phi_i^{'}$ is another such family of functions with the same property, then there exist constants $\alpha > 0, \beta_i, i \in N$ such that

$$\phi_i^{'} = \alpha\phi_i + \beta_i.$$

That is, the values are unique up to positive linear transformations. This restriction on the class of representing functions allows a meaningful interpretation of the scale values which goes beyond the statement of the mere ordering according to 'better than'. For any four alternatives a, b, c, d and any representing function ϕ, the quotient of the differences $(\phi(a) - \phi(b))/(\phi(c) - \phi(d))$ forms an 'invariant', meaning it is not dependent on the arbitrary choice of the specific representing function ϕ.

Early research in the field focused on finding axioms and conditions required to prove the representation theorems.[4] These guarantee the existence of mappings of empirical (preference) relations among objects onto numerical relations among real numbers preserving the underlying ordering. Further, emphasis was put on testing the structure between the components, for example, additive (theorem above), multiplicative, and polynomial. Conjoint measurement theory was not only considered as a beautiful theoretical framework for creating measurement scales from ordinal judgments on compound objects, but also as a powerful tool for practical purposes. Unfortunately, all the axioms were violated in a systematic way. Not even a stochastic version of the theory (Falmagne 1976) could rescue it. Nevertheless it made its way into such highly practical enterprises like marketing research. It did so without the original psychometric idealism and rigorousness of the founding but proved its value for practical purposes when applied in a pragmatic way (see, Huber 1987). Green and Srinivasan (1978) labeled the applied conjoint measurement *conjoint analysis* to differentiate the idealistic viewpoint from its practical application. The pragmatic approach simply trusts that overruling or ignoring the multiple violations of the axioms in practical judgment will in the end merely lead to a somewhat smoothed, basically correct representation of the fundamental convictions of subjects. Again, the success of practical applications, as for instance in the very worldly realm of marketing research, seems to justify this approach. In the following analysis therefore the SPSS CONJOINT procedure was used, utilizing a general linear model and multiple regression analysis.

4. Results

Two models were applied to the rank ordered data: (1) The discrete model assumes categorical factors, that is, it does not make assumptions about the

[4] For details Krantz/Luce/Suppes/Tversky 1971.

values of each factor's levels. (2) The linear model assumes a linear relation between the level values of each factor and the scale values to be estimated. For each expert the scale values ('utility' values) were estimated for both models. The utility values indicate the weights each factor level is given. Further, for each expert an importance score was determined for each factor for both models. An importance score of a given factor is defined as the utility range of that factor divided by the sum of all utility ranges. Since the estimates for both models are very similar, only the results of the less restrictive, discrete model are presented here in some detail. The results of the linear model are found in Appendix C. The utility values and the importance scores of each expert were aggregated across all experts. The results are shown in Table 3. The correlation between the observed and estimated preferences of the aggregated data are Pearson's R = .999 and Kendall's tau =.972, indicating a very good fit of the model to the data.

Factor	Level	Averaged Importance	Utility
Number of mismatches		51.41	
	0 MM		8.85
	1 MM		3.63
	3 MM		−3.57
	5 MM		−8.91
Matchability		8.12	
	low		1.11
	medium		−.14
	high		−.97
Waiting time		26.31	
	6 years		4.70
	4 years		1.70
	2 years		−1.96
	half a year		−4.45
Distance of kidney		7.58	
transportation	no		1.07
	short		.70
	medium		−.49
	far		−1.27
Donation willingness of		6.59	
the patient's country	high		.66
	medium		−.10
	low		−.56

Table 3: The averaged importance and utility scores for the factors and the level of factors, respectively. The results are based on 33 experts, each providing a rank order of 32 hypothetical patients with respect of receiver priority.

The score assigned to a patient is obtained by adding the utility values for each factor level plus a constant estimated by the program (16.06 in this case). For example, the total scores for patients # 28 and # 14 in Table 2 are $8.85+(-.97)+1.7+(-.49)+.66+16.06=25.81$ and $3.63+1.11+4.7+1.07+(-.10)+16.06=26.47$ respectively, leaving patient # 14 with a higher priority in receiving the organ.

5. Comparing the Results with ETKAS

The experts' evaluations were compared to the allocation point system of ETKAS in the following way. The experts' averaged importance score for each factor was defined as the utility range of that factor divided by the sum of utility ranges of all factors. To obtain a similar measure for the ETKAS system, the point range for each factor (see Table 1) was divided by the sum of point ranges of all factors.[5] Further, these scores were compared to weights of factors, recently published as mandatory allocation guidelines in *Deutsches Ärzteblatt* (2000) which are based on the German law for organ allocation (Transplantationsgesetz). Note, that only four factors are considered: number of mismatches (40%); mismatch probability (matchability) (10%); waiting time (30%); and distance of kidney transportation (20%) which was labeled ***time of conservation***.[6] The comparison of importance weights for allocating organs is shown in Figure 1.

The number of mismatches and the waiting time of a patient were the most important factors for both the experts and the allocation guidelines in allocating a donated kidney. For ETKAS the number of mismatches and the distance of kidney transportation received the highest points. Waiting time and donation willingness (national net import/export balance) were treated as being of equal importance. In contrast, the experts assigned donation willingness the lowest rank in their order of relevance, and it was even completely ignored by the allocation guidelines. The factors numbers of mismatches, matchability and waiting time—factors that are 100% patient-oriented—were similarly evaluated by all three evaluation schemes.

Moreover, there were some noticeable differences between the experts. 25 out of 33 experts evaluated ***number of mismatches*** as the most important factor for organ allocation. Seven experts evaluated it as the second most important factor. For seven out of 33 experts ***waiting time*** was the factor that received the highest values in their evaluation. 18 experts evaluated it as the second most important factor. One out of 33 experts considered ***donation willingness of patient's country*** as the most important one. However, 16 experts evaluated it as the least important factor. A list of all individual rankings is presented in Table 9 in Appendix C. The highest rank is indicated by 1, the lowest by 5. Same rank numbers (ties) for a given expert indicate same important values for the factors. Note that these rank orders only served to make a comparison

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[5] In this study the range for MM was 0 to 5. Therefore, the range for MM from ETKAS was 66 to 400 instead of 0 to 400, and the total amount of points 1134 instead of 1200. However, the difference between both measures was marginal.

[6] How the exact percentages were established is not evident from the article.

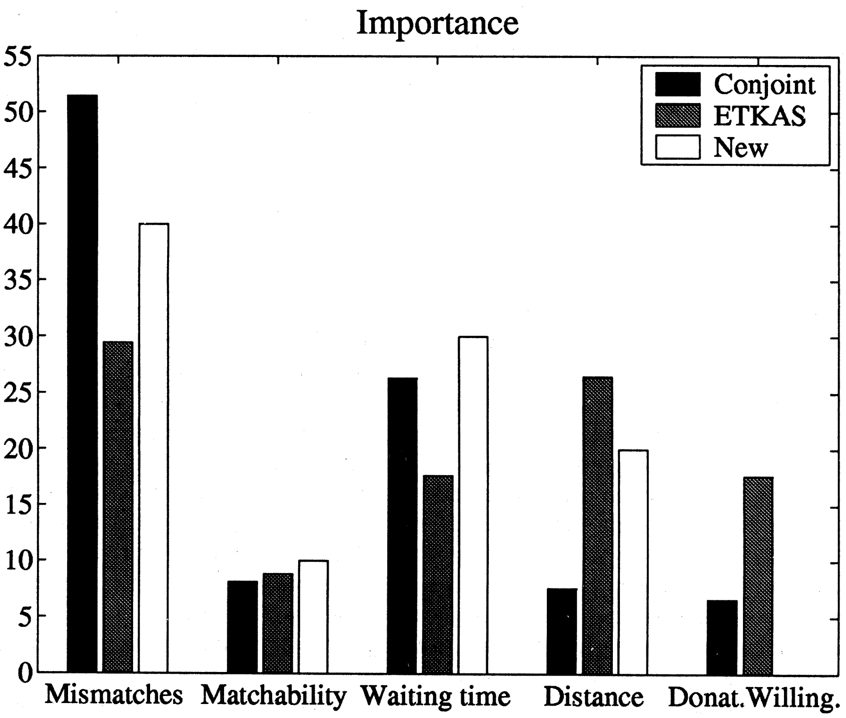


Figure 1: Averaged importance elicit by the conjoint procedure; the relative points assigned by ETKAS; and the weights according to the allocation guidelines, which is labeled *New*.

among the experts and do ***not*** reflect the actual weights given by each expert to each factor elucidated by the conjoint procedure. Furthermore, a cluster analysis using correlations between individual importance weights as a measure of similarity provided a similar result. One cluster could be interpreted as being oriented primarily toward medical factors, the other cluster as primarily fairness-oriented.

6. Conclusions

The Eurotransplant Kidney Allocation System (ETKAS) was installed to adjust long waiting times and international exchange balances, while still providing an optimal HLA–mismatch distribution (De Meester et al. 1998). ETKAS emerged from the XCOMB model by Wujciak and Opelz (1993a,b), who applied computer simulation studies to create an allocation algorithm. The present study investigated how experts would allocate a donated organ to patients on the waiting list with respect to the five allocation factors proposed in the ETKAS. This is the first time that experts' evaluations have been compared to the existing allocation point-scores of ETKAS. Moreover, the evaluations were compared to weights of factors recently published as mandatory allocation guidelines in *Deutsches Ärzteblatt* (2000). The investigation was carried out using a conjoint analysis. Overall, the results indicate a relatively high degree of agreement between the experts' opinions and the existing allocation system ETKAS, and an even higher one for the allocation guidelines (NEW). In particular, the factors *Mismatches, Matchability*, and *Waiting time* were the most widely agreed upon. For these three factors the smallest number of reversals (change of preference during the evaluation) could be observed. The factors *Mismatches* and *Waiting time* received the highest importance values from the experts which is in perfect accordance with the allocation guidelines. ETKAS gives more weight to the factor *Distance* and the same weights for *Waiting time* and *Donation willingness* (International exchange balances). Note that the factor *Donation* willingness does not appear in the allocation guidelines (NEW). This is surprising since ETKAS was established in particular to adjust the international exchange balance (see De Meester et al. 1998).

To conclude, the present study has shown that the experts' evaluations are very close to the point system obtained by computer simulations, at least for the factors *Mismatches, Matchability*, and *Waiting time*, so that these (and experts') evaluations could well be included in future adjustment of allocation systems. Furthermore, a comparison of experts' judgments from other member countries of Eurotransplant, in particular with respect to the factor *Donation willingness*, would be interesting, and is envisaged for the near future.

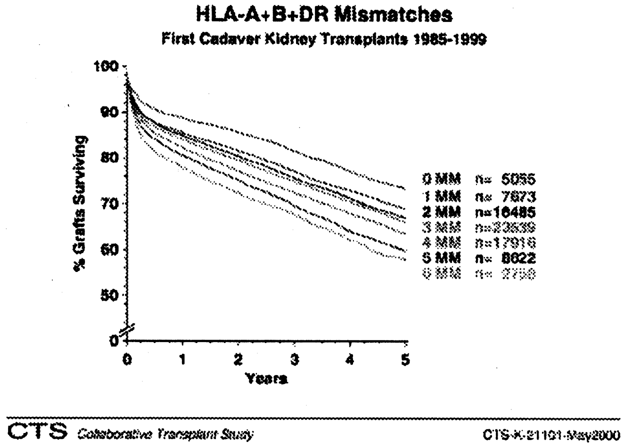
Appendix A

Attached to this letter please find 32 cards on which 'patients' are described by five criteria which are relevant for the organ allocation. The actual values of the criteria may differ for each possible recipient. A list of the criteria and the values used in this research are:

Criteria	possible values
Number of mismatches:	0,1,3,5
Matchability:	high/medium/low
Waiting time:	half a year, 2 years, 4 years, 6 years
Distance of kidney transportation:	no/short/medium/far
Donation willingness of patient's country:	high/medium/low

Just to remind you what is meant by the criteria:

The relation between **Number of mismatches** and the probability of survival of the graft is presented in the following figure:



http:www.ctstransplant.orgpagesdatahtml_allcts-k-21101-may2000.html

Matchability is the probability to receive an organ with at most 1 MM among the next 1000 donors.

Waiting time starts with the first day of dialysis. Waiting times beyond 6 years do not count.

Distance of kidney transportation depends on the location of transplantation in the following way:

no	at the donor's hospital
short	at the local transplantation center
medium	at a national transplantation center
long	at an international transplantation center

Donation willingness of the patient's country is defined as the difference between the number of exported and imported kidneys.

Your task is to rank order the 'patients' (cards) such that the order reflects your opinion on the priority with which a patient should receive the organ. It is not important for your evaluation to consider how the allocation is done practice. We are interested in how you would allocate the organ according to your expertise.

It is not easy to rank order the cards if you consider all criteria which we would, of course, like you to do. You will find it helpful, first, to sort the cards, for example, into three groups, and then rank order the cards within a group.

After you have rank ordered the cards according to your evaluation of recipient's priority, please write a 1 on the card with the highest

priority, a 2 on the card with the second highest priority, and so on until rank 32.

Included: One set of cards

Appendix B

Patient's ID #	Number of mismatches	Matchability	Waiting time (in years)	Distance of transportation	Donation willingness of patient's country
1	0	medium	2	far	medium
2	5	low	2	medium	low
3	1	low	1/2	short	high
4	5	medium	1/2	medium	high
5	5	medium	6	short	high
6	0	low	6	no	high
7	3	low	4	short	high
8	1	low	1/2	far	low
9	1	medium	2	short	low
10	3	medium	1/2	no	high
11	5	high	1/2	no	low
12	1	medium	4	medium	medium
13	5	high	6	far	medium
14	1	low	6	no	medium
15	0	low	1/2	short	medium
16	5	low	4	short	medium
17	5	low	4	far	high
18	3	low	4	far	low
19	1	high	2	far	high
20	1	high	4	no	high
21	5	low	2	no	high
22	0	medium	4	no	low
23	3	low	2	no	medium
24	3	low	2	medium	high
25	3	high	1/2	medium	medium
26	3	medium	6	far	high
27	0	low	1/2	far	high
28	0	high	4	medium	high
29	0	low	6	medium	low
30	3	high	6	short	low
31	0	high	2	short	high
32	1	low	6	medium	high

Table 4: 32 hypothetical patients with five factors and the respective levels

	Expert's ID #										
	01	02	03	04	05	06	07	08	09	10	11
Patient's ID #	06	06	06	15	29	06	06	06	29	06	06
	29	29	29	27	06	29	14	29	06	14	14
	14	27	14	31	14	15	32	14	14	29	32
	32	15	32	28	32	27	29	32	32	32	29
	30	22	22	01	30	22	03	22	26	28	22
	05	01	12	22	26	31	22	28	30	20	07
	26	28	28	06	05	28	12	01	05	22	26
	13	31	20	29	13	01	28	31	13	12	20
	22	32	01	19	22	14	20	15	22	31	28
	28	14	09	20	28	32	09	27	28	09	15
	12	03	15	08	12	20	01	12	12	19	03
	20	08	27	03	20	12	31	20	20	01	31
	07	12	03	32	07	03	19	09	18	27	12
	16	09	08	09	18	08	15	19	07	03	09
	18	20	26	12	16	09	27	03	16	15	27
	17	19	07	14	17	19	08	08	17	08	01
	01	07	18	25	01	07	11	26	01	30	08
	31	18	30	10	31	18	21	30	31	26	05
	15	24	31	23	09	23	17	07	09	07	30
	27	23	19	24	19	24	16	18	19	18	10
	09	26	23	07	23	10	05	24	23	23	19
	03	30	24	18	24	26	26	23	24	24	23
	19	10	17	30	02	30	30	10	02	10	24
	08	25	16	26	21	25	13	25	21	25	16
	23	17	05	11	15	16	07	05	15	05	18
	21	16	13	13	27	17	18	13	27	13	17
	24	21	21	16	08	21	23	16	08	16	13
	02	02	02	17	03	02	24	17	03	17	21
	10	05	10	05	10	05	02	21	10	21	02
	04	04	25	04	25	04	10	02	25	11	04
	11	13	04	02	11	11	04	04	04	02	25
	25	11	11	21	04	13	25	11	11	04	11

Table 5: 32 hypothetical patients rank ordered by experts according to recipient's priority

	Expert's ID #										
	12	13	14	15	16	17	18	19	20	21	22
Patient's ID #	06	06	06	06	06	06	06	06	06	29	06
	29	29	32	29	14	29	15	29	29	22	29
	22	14	14	22	29	32	29	27	15	06	15
	14	32	29	28	32	14	22	15	27	14	22
	32	22	26	14	15	26	27	22	22	30	27
	28	20	30	32	27	22	01	01	01	15	01
	31	28	22	27	28	30	28	28	28	32	31
	01	12	20	31	31	28	31	31	31	09	28
	15	15	12	01	03	07	14	32	14	28	14
	27	03	28	15	08	18	32	14	32	12	32
	20	09	07	12	21	12	03	03	08	18	03
	12	01	18	09	20	20	08	08	03	01	08
	09	31	05	03	07	31	09	12	12	20	12
	03	23	13	08	16	27	12	09	09	31	09
	08	08	16	20	23	15	20	20	20	23	20
	30	19	17	19	05	03	19	19	19	08	19
	26	27	09	30	17	19	07	07	05	16	23
	19	07	01	23	02	05	23	18	26	27	07
	07	30	31	24	22	01	24	23	30	26	24
	18	26	19	07	01	13	18	24	13	05	18
	23	18	23	26	12	09	26	26	18	02	10
	24	24	24	18	18	24	30	10	07	03	26
	05	10	21	10	24	23	25	30	23	13	30
	16	25	02	25	09	17	10	25	24	07	25
	17	16	03	16	10	16	21	16	10	11	21
	10	21	15	21	26	21	16	17	25	21	02
	25	17	27	17	13	02	17	21	16	24	16
	21	02	08	05	30	08	02	02	17	10	17
	02	05	10	02	19	10	05	05	02	17	05
	13	13	25	11	25	25	11	04	21	19	04
	04	04	04	04	04	11	04	13	04	25	11
	11	11	11	13	11	04	13	11	11	04	13

Table 6: 32 hypothetical patients rank ordered by experts according to recipient's priority

	Expert's ID #										
	23	24	25	26	27	28	29	30	31	32	33
Patient's ID #	06	06	06	06	06	29	06	06	06	06	29
	20	29	32	29	29	06	29	29	14	29	06
	28	27	26	28	22	22	22	31	29	22	22
	14	31	05	22	28	28	28	28	32	15	28
	31	28	28	31	01	01	01	15	22	31	14
	32	15	20	01	31	31	31	32	20	28	15
	22	05	07	27	14	15	15	19	28	01	32
	30	32	17	15	32	27	27	14	12	27	20
	29	22	31	32	12	14	14	01	18	14	08
	26	21	19	14	20	32	32	20	26	30	19
	05	20	24	20	26	12	12	10	30	07	09
	12	14	21	12	07	20	09	22	05	20	01
	19	16	27	19	30	09	03	03	31	23	03
	07	17	03	09	05	19	20	27	09	09	12
	13	26	10	03	15	08	08	07	13	03	27
	01	23	04	08	03	03	19	09	01	10	31
	09	01	14	26	27	30	07	12	07	05	26
	10	07	13	30	09	26	18	16	23	16	30
	03	03	16	07	18	18	23	05	19	21	18
	15	24	12	18	19	07	24	21	24	26	23
	23	30	01	24	23	23	26	30	16	32	07
	27	10	23	23	24	24	10	24	17	18	24
	21	02	15	10	10	10	30	23	15	19	10
	24	12	25	25	25	25	05	08	03	08	25
	16	13	29	05	08	13	16	13	27	02	16
	25	18	30	13	13	05	17	17	08	04	13
	17	09	22	17	17	16	25	18	21	17	17
	18	04	18	16	16	17	13	26	02	13	21
	11	19	09	21	21	21	21	04	10	11	05
	04	11	02	02	02	02	02	11	25	12	11
	08	08	08	04	11	11	04	25	11	24	04
	02	25	11	11	04	04	11	02	04	25	02

Table 7: 32 hypothetical patients rank ordered by experts according to recipient's priority

Appendix C

		Discrete Model		Linear Model	
Factor	Level	Averaged Importance	Utility	Averaged Importance	Utility
Number of mismatches		51.41		52.51	
	0 MM		8.85		−6.05
	1 MM		3.63		−12.10
	3 MM		−3.57		−18.15
	5 MM		−8.12		−24.20
Matchability		8.12		7.59	
	low		1.11		−1.06
	medium		−.14		−2.11
	high		−.97		−3.17
Waiting time		26.31		27.12	
	6 years		4.70		−3.12
	4 years		1.70		−6.23
	2 years		−1.96		−9.35
	half a year		−4.45		−12.46
Distance of kidney transportation		7.58		6.77	
	no		1.07		−.82
	short		.70		−1.62
	medium		−.49		−2.46
	far		−1.27		−3.28
Donation willingness of the patient's country		6.59		6.02	
	high		.66		−.62
	medium		−.10		−1.25
	low		−.56		−1.87
Constant			16.06		44.41

Table 8: The averaged importance and utility scores for the factors and the level of factors, respectively, for the discrete and linear model. The results are based on 33 experts, each providing a rank order of 32 hypothetical patients with respect of receiver priority.

The correlation coefficients for the discrete model are: Pearson's R = .999 and Kendall's tau = .972; for the linear model Pearson's R = .997 and Kendall's tau = .952, indicating that the discrete model describes the data slightly better.
The linear model assumes a linear relation between a factor and the ranks, e.g., fewer mismatches are preferred. The following reversals of this assumed relationship could be observed: for one expert 3 reversals; for two experts 2 reversals, and for 13 experts one reversal. These reversals occurred for the factors: Donation willingness (11 reversals), Matchability (5 reversals), Distance (3 reversals), Waiting time (1 reversal), and Mismatches (no reversal).

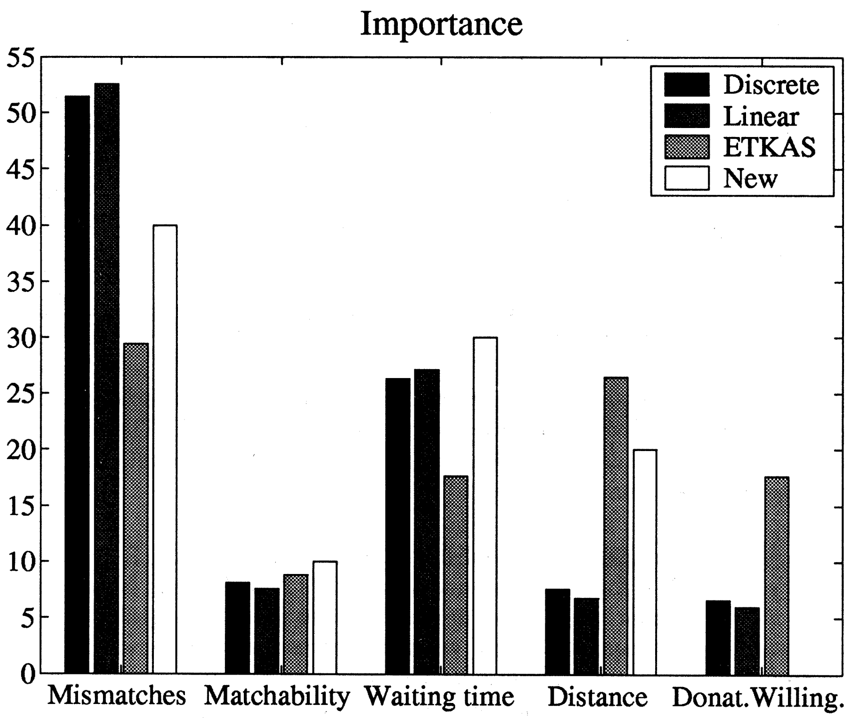


Figure 2: Averaged importance elicited by the conjoint procedure applying a discrete model and a linear model; the relative points assigned by ETKAS; and the weights according to the allocation guidelines, which is labeled *New*.

Expert	Number of mismatches	Matchability	Waiting time	Distance	Donation willingness
6,16	1	2	3	4	5
2,19	1	2	3	5	4
18,22	1	2	4	3	5
8,12,15,20,29	1	3	2	4	5
3,4	1	3	2	5	4
7,11,13	1	4	2	3	5
26	1	4	2	4	3
32	1	4	3	2	5
10,27,33	1	5	2	3	4
21,24,28	1	5	2	4	3
30	1	5	4	2	3
1	2	3	1	4	5
17	2	3	1	5	4
14,23	2	4	1	3	5
9	2	4	1	5	3
31	2	5	1	3	4
5	2	5	1	4	3
25	3	4	2	5	1

Table 9: Pattern of importance ranking of each expert for the factors. Note that these values do not reflect the actual experts' importance values.

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