Meaning in colexification: beyond single edges and towards a network perspective

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Loading libraries

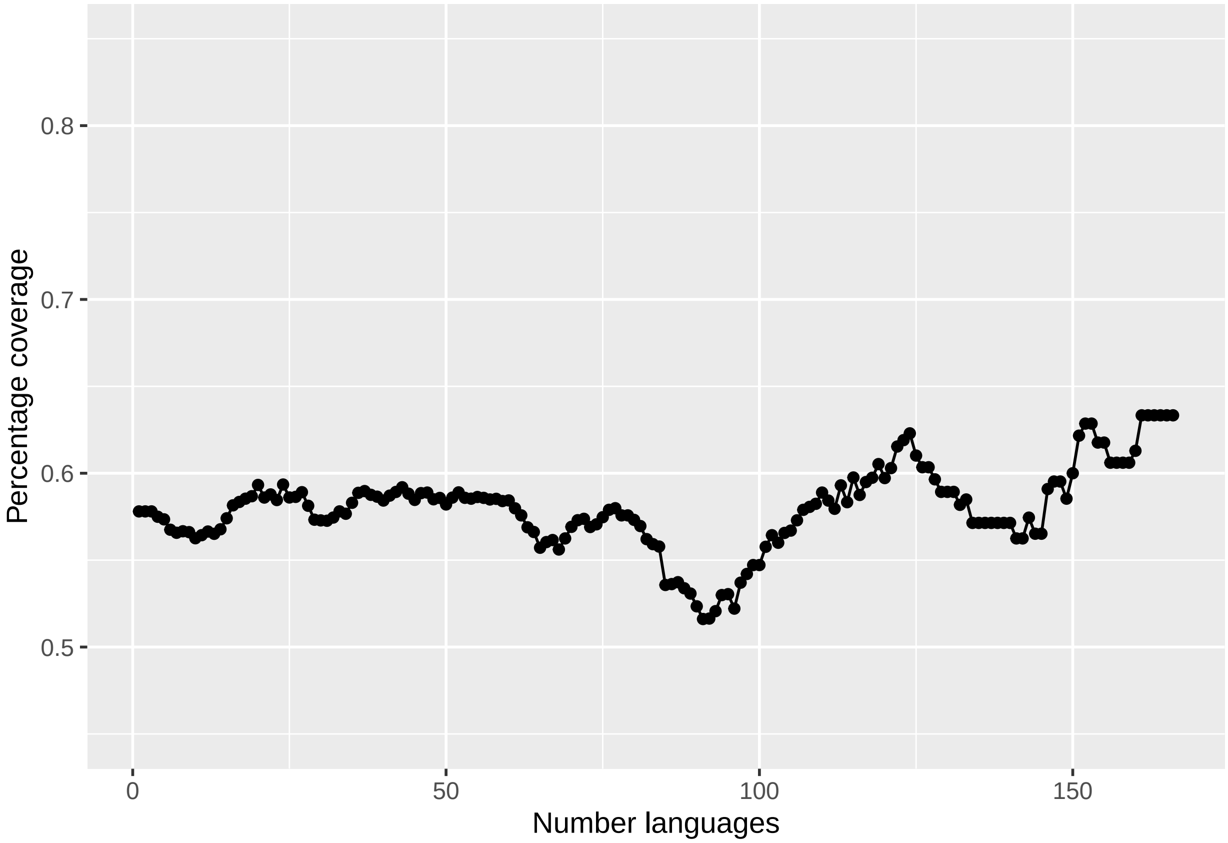
Loading data

Loading function for computing the distances in the network

Computing the distances in the network (it might take some time)

Loading and preprocessing the distances on the network

Figure 2 SI: Coverage of MTurk questions on Clics3



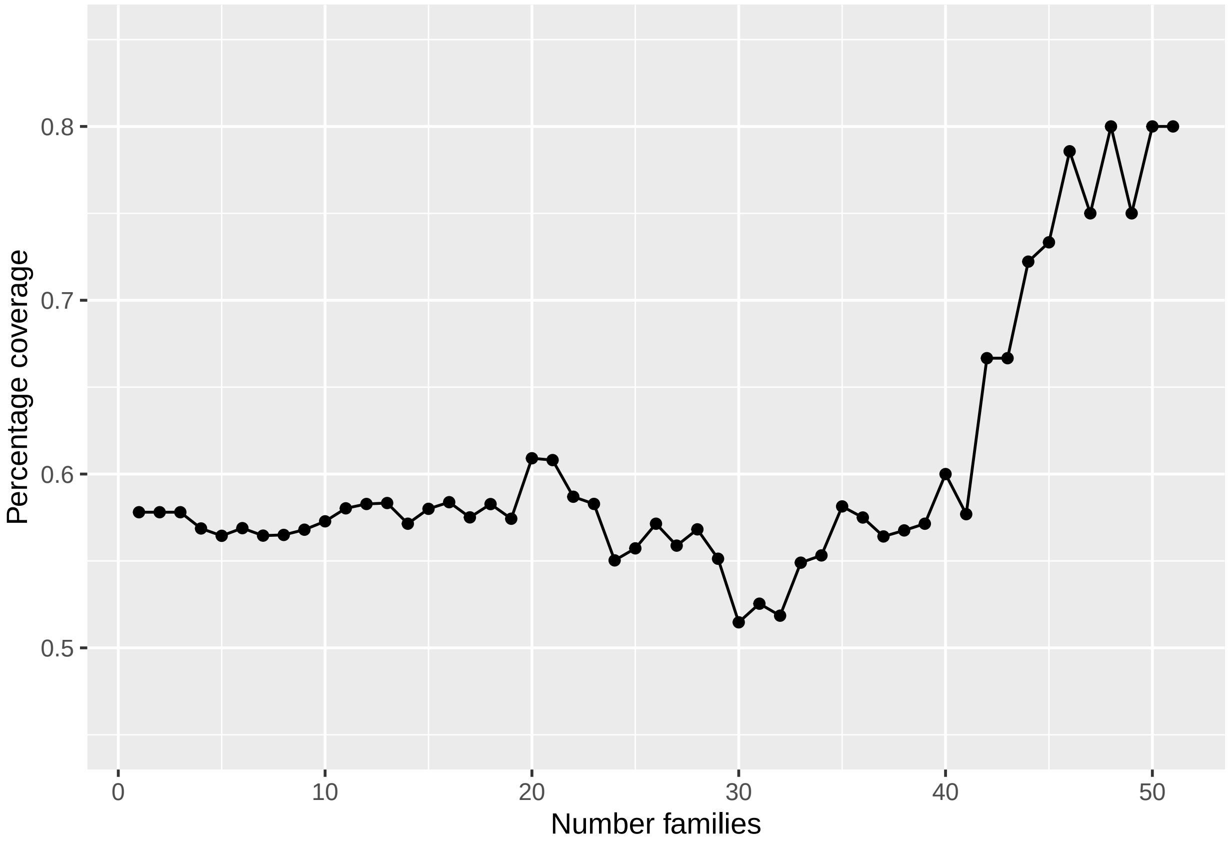


Table 1 - correlation of MTurk results with ground truth datasets (SimLex-999, SimVerb-3500, MEN)

	dataset	corr_mean	corr_ci1	corr_ci2	n	pval
cor	SimLex-999	0.50	0.27	0.68	53	<0.001
cor1	SimVerb-3500	0.57	0.45	0.67	145	<0.001
cor2	MEN	0.63	0.44	0.77	56	<0.001

Table 1 si - correlation of the word association data with MTurk annotations

	dataset	corr_mean	corr_ci1	corr_ci2	n	pval
cor	SWOW	0.26	0.20	0.31	1024	<0.001
cor1	USF	0.25	0.19	0.31	880	<0.001

LINK LEVEL

Table 2 - correlation of similarity data with colexification strength (link level) Table 2 SI rows 1, 2, 3, 4, 7 (SimLex, SimVerb, MEN, FastText and MTurk annotations) second column - number of overlapping edges Table 3 SI: correlation with the mode of the MTurk annotations

	dataset	corr_lang	corr_lang_ci1	corr_lang_ci2	pval_lang	corr_fam	corr_fam_ci1	corr_fam_ci2	pval_fam	n
cor	SimLex-999	0.27	0.01	0.49	0.04	0.38	0.14	0.58	0.003	59
cor1	SimVerb-3500	0.23	0.08	0.37	0.003	0.25	0.10	0.38	0.001	168

	dataset	corr_lang	corr_lang_ci1	corr_lang_ci2	pval_lang	corr_fam	corr_fam_ci1	corr_fam_ci2	pval_fam	n
cor2	MEN	0.32	0.06	0.54	0.016	0.35	0.09	0.56	0.009	56
cor3	FastText	0.16	0.12	0.20	<0.001	0.19	0.15	0.23	<0.001	2441
cor4	Annotations	0.25	0.21	0.29	<0.001	0.32	0.28	0.35	<0.001	2441

dataset	n_link	perc_link
SimLex-999	59	1.4
SimVerb-3500	168	4.0
MEN	56	1.3
FastText	2441	57.7
Annotations	2441	57.7

	corr_lang	corr_lang_ci1	corr_lang_ci2	pval_lang	corr_fam	corr_fam_ci1	corr_fam_ci2	pval_fam	n
cor	0.22	0.18	0.25	<0.001	0.27	0.23	0.31	<0.001	2441

Table 3 - correlation of colexification strength with word association tasks Table 2 si rows 5,6 (SWOW and USF), second column (edges)

	dataset	corr_lang	corr_lang_ci1	corr_lang_ci2	pval_lang	corr_fam	corr_fam_ci1	corr_fam_ci2	pval_fam	n
cor	SWOW	0.15	0.09	0.20	<0.001	0.18	0.13	0.24	<0.001	1189
cor1	USF	0.08	0.02	0.14	0.012	0.14	0.08	0.20	<0.001	982

dataset	n_link	perc_link
SWOW	1189	28.1
USF	982	23.2

Table 4 SI - Results on a common dataset (FastText, SWOW, annotations)

	dataset	corr_lang	corr_lang_ci1	corr_lang_ci2	pval_lang	corr_fam	corr_fam_ci1	corr_fam_ci2	pval_fam	corr_dist_lang	corr_dist_lang_ci1	corr_dist_lang_ci2	pval_dist_lang	corr_dist_fam	corr_dist_fam_ci1	corr_dist_fam_ci2	pval_dist_fam
cor	Annotations	0.11	0.05	0.17	<0.001	0.14	0.08	0.20	<0.001	0.12	0.06	0.18	<0.001	0.11	0.05	0.17	<0.001
cor1	FastText	0.04	-0.02	0.11	0.156	0.07	0.01	0.13	0.025	0.12	0.06	0.18	<0.001	0.14	0.08	0.20	<0.001
cor2	SWOW	0.14	0.08	0.20	<0.001	0.18	0.12	0.24	<0.001	0.20	0.14	0.26	<0.001	0.20	0.14	0.25	<0.001

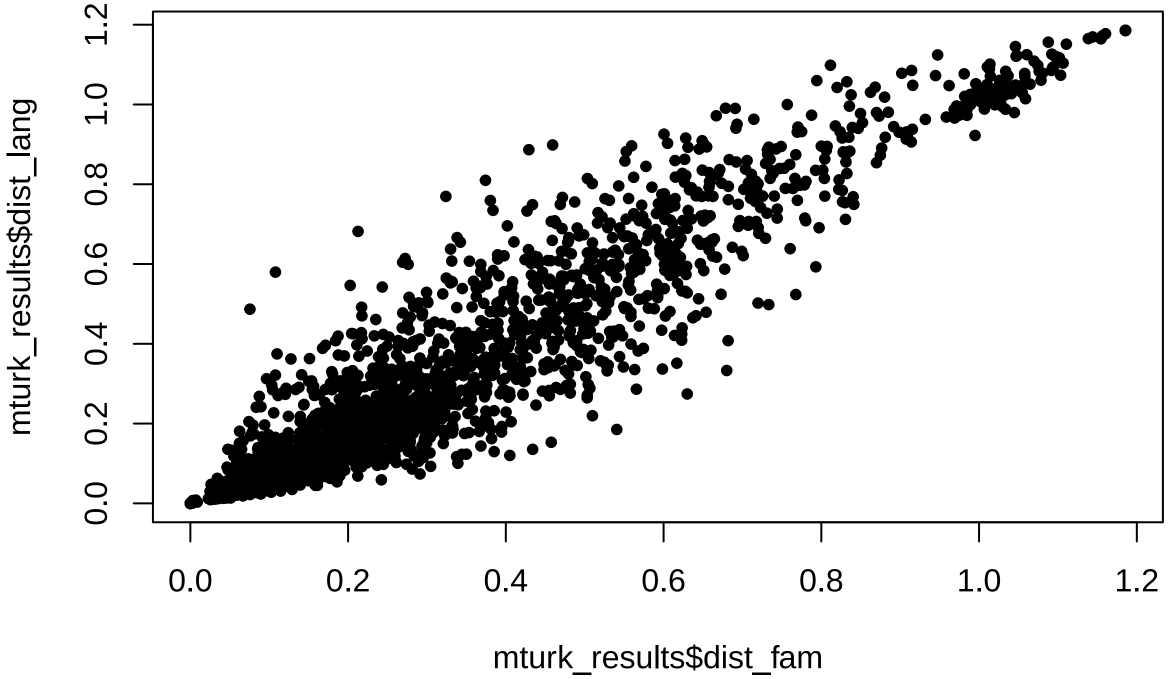
NETWORK LEVEL

Figure 3- correlation between distances and colexification weigths

```
##
##  Pearson's product-moment correlation
##
## data:  mturk_results$dist_fam and mturk_results$dist_lang
## t = 162.74, df = 2658, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
```

```
##  0.9497103 0.9566520
## sample estimates:
##       cor
## 0.9533069
```

```
##
##  Pearson's product-moment correlation
##
## data:  mturk_results$FamilyWeight and mturk_results$LanguageWeight
## t = 78.527, df = 2439, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.8348734 0.8573877
## sample estimates:
##       cor
## 0.8465086
```



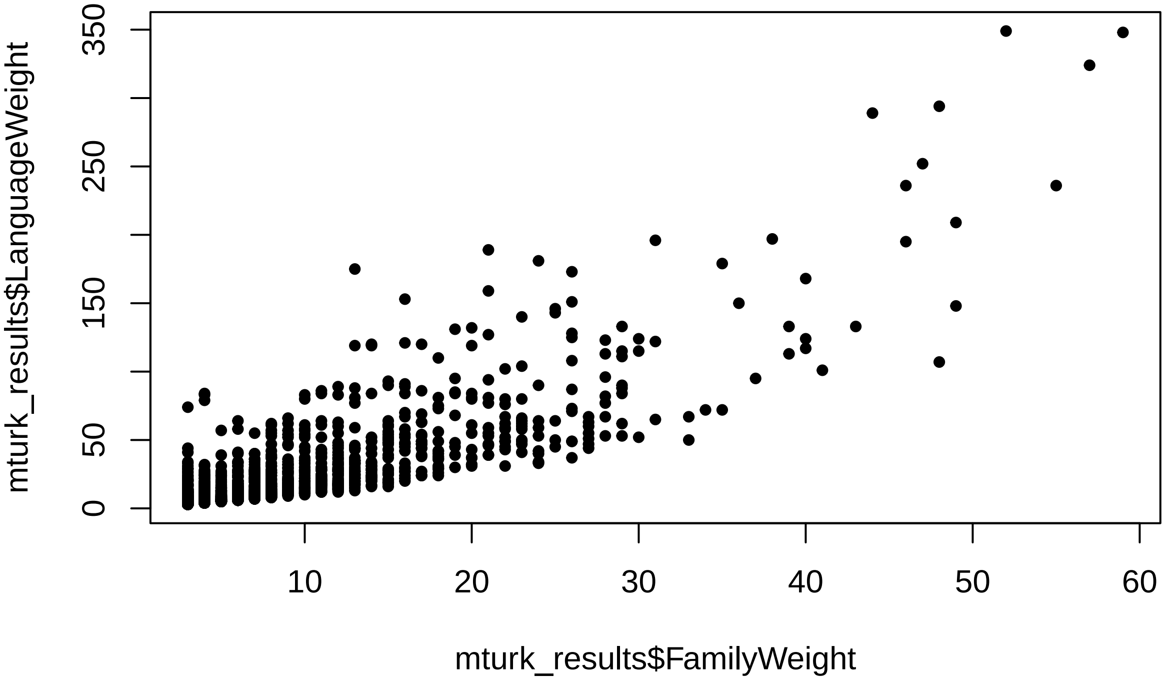


Table 4 - correlation of similarity data with distance on language weights (network level) Table 2 SI rows 1, 2, 3, 4, 7 (SimLex, SimVerb, MEN, FastText and MTurk annotations) third column - number of overlapping distances and Table 6 SI: correlation with the distance computed with family weights

```
##
##   Results of a comparison of two overlapping correlations based on dependent groups
##
## Comparison between r.jk (mean, dist_lang) = 0.3129 and r.jh (mean, LanguageWeight) = 0.2519
## Difference: r.jk - r.jh = 0.061
## Related correlation: r.kh = 0.4237
## Data: mturk_results: j = mean, k = dist_lang, h = LanguageWeight
## Group size: n = 2441
## Null hypothesis: r.jk is equal to r.jh
## Alternative hypothesis: r.jk is greater than r.jh (one-sided)
## Alpha: 0.05
##
## pearson1898: Pearson and Filon's z (1898)
##   z = 2.9648, p-value = 0.0015
##   Null hypothesis rejected
##
## hotelling1940: Hotelling's t (1940)
##   t = 2.9809, df = 2438, p-value = 0.0015
##   Null hypothesis rejected
##
## williams1959: Williams' t (1959)
##   t = 2.9654, df = 2438, p-value = 0.0015
##   Null hypothesis rejected
##
## olkin1967: Olkin's z (1967)
##   z = 2.9648, p-value = 0.0015
##   Null hypothesis rejected
##
## dunn1969: Dunn and Clark's z (1969)
##   z = 2.9625, p-value = 0.0015
##   Null hypothesis rejected
##
## hendrickson1970: Hendrickson, Stanley, and Hills' (1970) modification of Williams' t (1959)
##   t = 2.9809, df = 2438, p-value = 0.0015
##   Null hypothesis rejected
##
## steiger1980: Steiger's (1980) modification of Dunn and Clark's z (1969) using average correlations
##   z = 2.9614, p-value = 0.0015
##   Null hypothesis rejected
##
## meng1992: Meng, Rosenthal, and Rubin's z (1992)
##   z = 2.9604, p-value = 0.0015
##   Null hypothesis rejected
##   95% confidence interval for r.jk - r.jh: 0.0224 0.1102
##   Null hypothesis rejected (Lower boundary > 0)
##
## hittner2003: Hittner, May, and Silver's (2003) modification of Dunn and Clark's z (1969) using a bac
##   z = 2.9612, p-value = 0.0015
##   Null hypothesis rejected
##
## zou2007: Zou's (2007) confidence interval
##   95% confidence interval for r.jk - r.jh: 0.0206 0.1013
##   Null hypothesis rejected (Lower boundary > 0)
```

	dataset	corr_dist_lang	corr_dist_lang_ci1	corr_dist_lang_ci2	pval_dist_lang	n
cor	SimLex-999	0.47	0.36	0.56	<0.001	220
cor1	SimVerb-3500	0.49	0.42	0.55	<0.001	525
cor2	MEN	0.40	0.31	0.48	<0.001	382
cor3	FastText	0.30	0.26	0.33	<0.001	2641
cor4	Annotations	0.37	0.34	0.40	<0.001	2660

dataset	n_dist	perc_dist
SimLex-999	220	0.0
SimVerb-3500	525	0.0
MEN	382	0.0
FastText	2641	0.2
Annotations	2660	0.2

	dataset	corr_dist_fam	corr_dist_fam_ci1	corr_dist_fam_ci2	pval_dist_fam	n
cor	SimLex-999	0.46	0.35	0.56	<0.001	220
cor1	SimVerb-3500	0.49	0.42	0.55	<0.001	525
cor2	MEN	0.41	0.32	0.49	<0.001	382
cor3	FastText	0.31	0.28	0.34	<0.001	2641
cor4	Annotations	0.37	0.34	0.41	<0.001	2660

Table 2 SI rows 5,6 (USF, SWOW) third column - number of overlapping distances

dataset	n_dist	perc_dist
SWOW	10183	0.9
USF	12505	1.1

Table 5 - correlation of word association tasks and distance on language weights Table 7 SI - correlation of association tasks data and distance on family weights

	dataset	corr_dist_lang	corr_dist_lang_ci1	corr_dist_lang_ci2	pval_dist_lang	n
cor	SWOW	0.29	0.27	0.30	<0.001	10183
cor1	USF	0.19	0.17	0.21	<0.001	12505

	dataset	corr_dist_fam	corr_dist_fam_ci1	corr_dist_fam_ci2	pval_dist_fam	n
cor	SWOW	0.29	0.27	0.3	<0.001	10183
cor1	USF	0.19	0.17	0.2	<0.001	12505

Table 6 - linear regression models for distance on the language weights (network level)

```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$cossim) +
##     scale(mturk_results$dist_lang))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.86029 -0.60103  0.00191  0.60361  2.13918
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     3.04507    0.01640  185.63   <2e-16 ***
## scale(mturk_results$cossim)     0.36750    0.01704   21.56   <2e-16 ***
## scale(mturk_results$dist_lang)  0.23172    0.01704   13.60   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8286 on 2553 degrees of freedom
##   (104 observations deleted due to missingness)
## Multiple R-squared:  0.2554, Adjusted R-squared:  0.2548
## F-statistic: 437.8 on 2 and 2553 DF,  p-value: < 2.2e-16
```

```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$cossim))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.70795 -0.63517  0.00672  0.64982  2.47019
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  3.05426    0.01697  179.98   <2e-16 ***
## scale(mturk_results$cossim)  0.43082    0.01697   25.38   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.858 on 2554 degrees of freedom
##   (104 observations deleted due to missingness)
## Multiple R-squared:  0.2014, Adjusted R-squared:  0.2011
## F-statistic: 644.3 on 1 and 2554 DF,  p-value: < 2.2e-16
```

```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$dist_lang))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.82891 -0.68647  0.02153  0.67464  2.27810
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     3.01244    0.01749  172.20   <2e-16 ***
## scale(mturk_results$dist_lang)  0.36004    0.01750   20.58   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9022 on 2658 degrees of freedom
## Multiple R-squared:  0.1374, Adjusted R-squared:  0.1371
## F-statistic: 423.4 on 1 and 2658 DF,  p-value: < 2.2e-16
```

#Df	LogLik	Df	Chisq	Pr(>Chisq)
4	-3144.854	NA	NA	NA
3	-3234.240	-1	178.7726	0

Table 8 SI - linear regression models for distance on the family weights (network level)

```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$cossim) +
##     scale(mturk_results$dist_fam))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.83256 -0.60600  0.00525  0.60277  2.13105
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    3.04416    0.01643  185.24   <2e-16 ***
## scale(mturk_results$cossim)    0.36609    0.01713   21.37   <2e-16 ***
## scale(mturk_results$dist_fam)  0.22847    0.01721   13.28   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.83 on 2553 degrees of freedom
##   (104 observations deleted due to missingness)
## Multiple R-squared:  0.253,  Adjusted R-squared:  0.2524
## F-statistic: 432.4 on 2 and 2553 DF,  p-value: < 2.2e-16
```

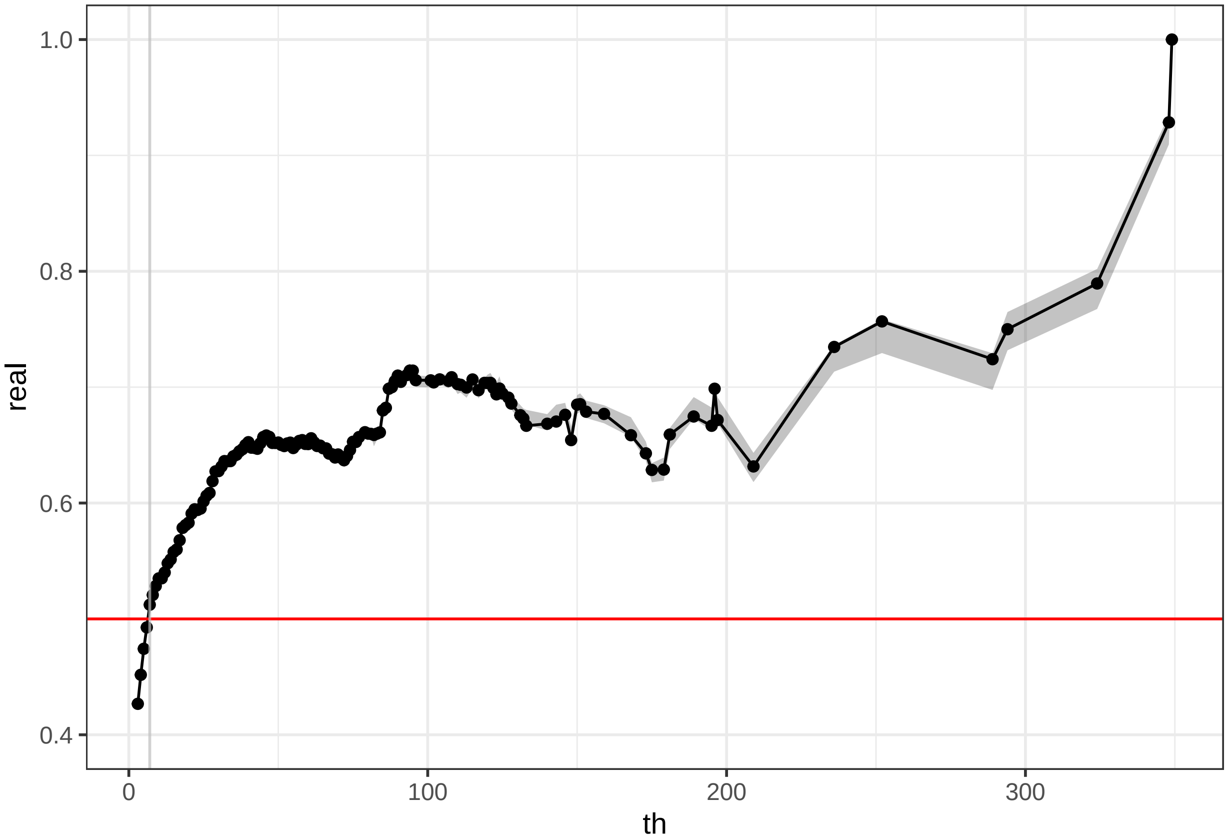
```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$cossim))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.70795 -0.63517  0.00672  0.64982  2.47019
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  3.05426    0.01697  179.98   <2e-16 ***
## scale(mturk_results$cossim)  0.43082    0.01697   25.38   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.858 on 2554 degrees of freedom
##   (104 observations deleted due to missingness)
## Multiple R-squared:  0.2014, Adjusted R-squared:  0.2011
## F-statistic: 644.3 on 1 and 2554 DF,  p-value: < 2.2e-16
```

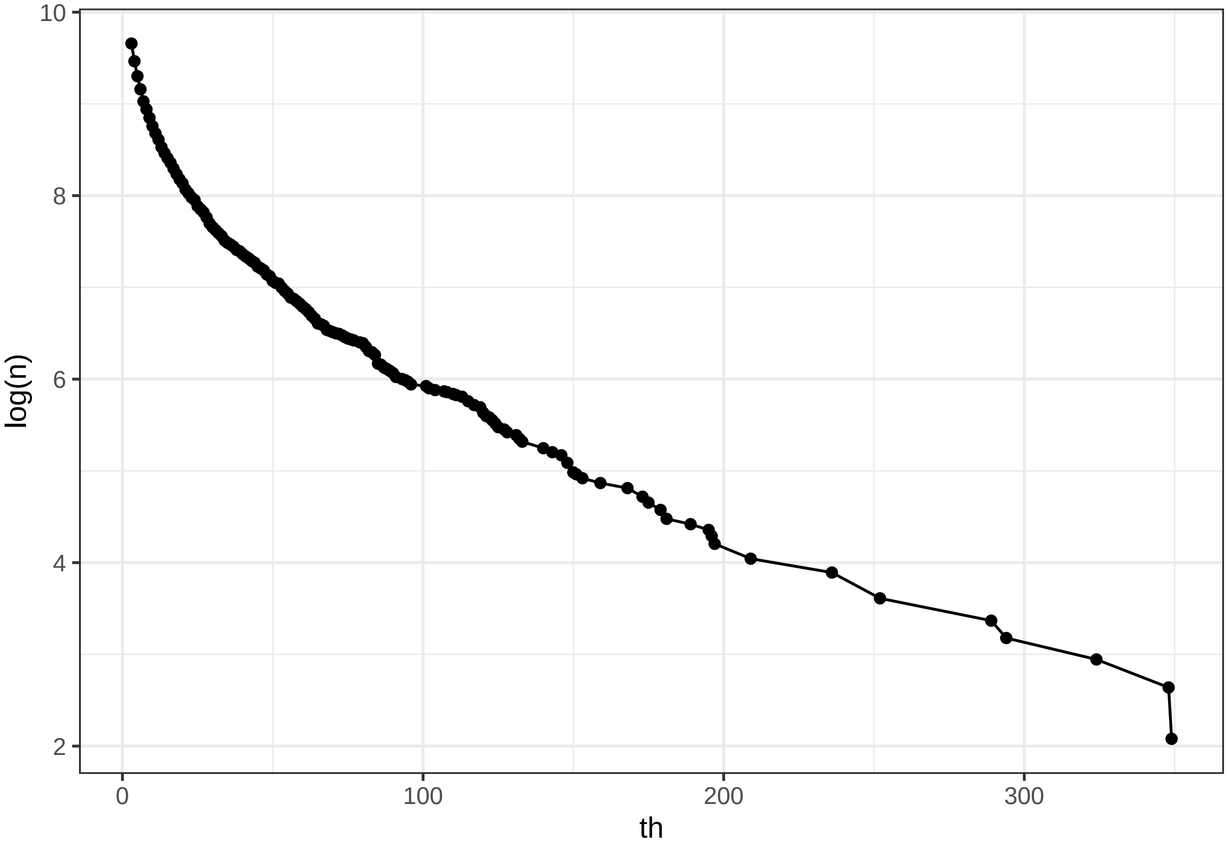
```
##
## Call:
## lm(formula = mturk_results$mean ~ scale(mturk_results$dist_fam))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.89440 -0.68497  0.00716  0.67574  2.29344
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    3.01244    0.01747  172.40   <2e-16 ***
## scale(mturk_results$dist_fam)  0.36263    0.01748   20.75   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9012 on 2658 degrees of freedom
## Multiple R-squared:  0.1394, Adjusted R-squared:  0.1391
## F-statistic: 430.5 on 1 and 2658 DF,  p-value: < 2.2e-16
```

#Df	LogLik	Df	Chisq	Pr(>Chisq)
4	-3148.924	NA	NA	NA
3	-3234.240	-1	170.6308	0

THRESHOLD FOR NOISE

Figure 4 - Estimation of the threshold for noise


real
1.0
0.8
0.6
0.4
0
100
200
300
th


log(n)
10
8
6
4
2
0
100
200
300
th

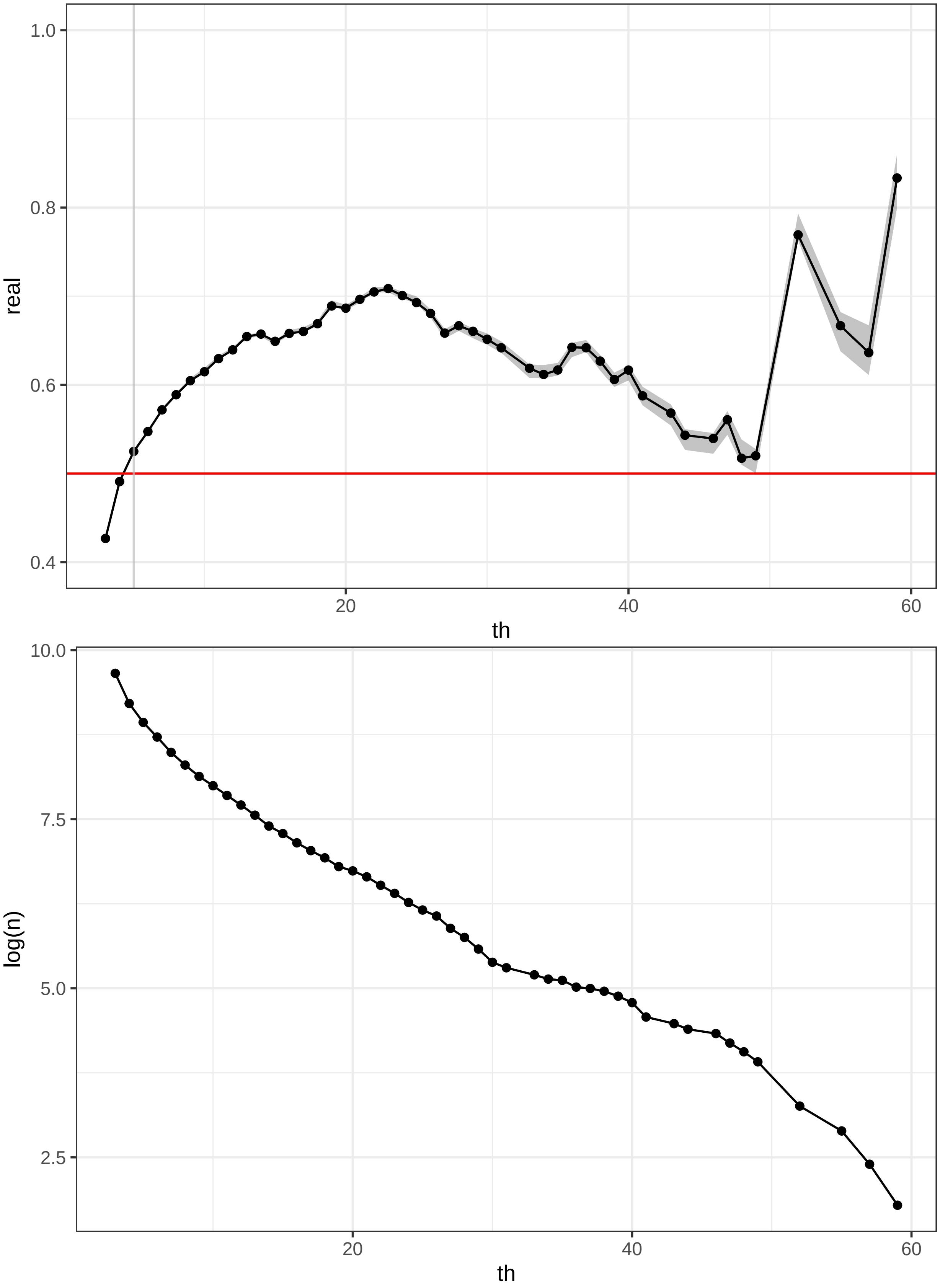
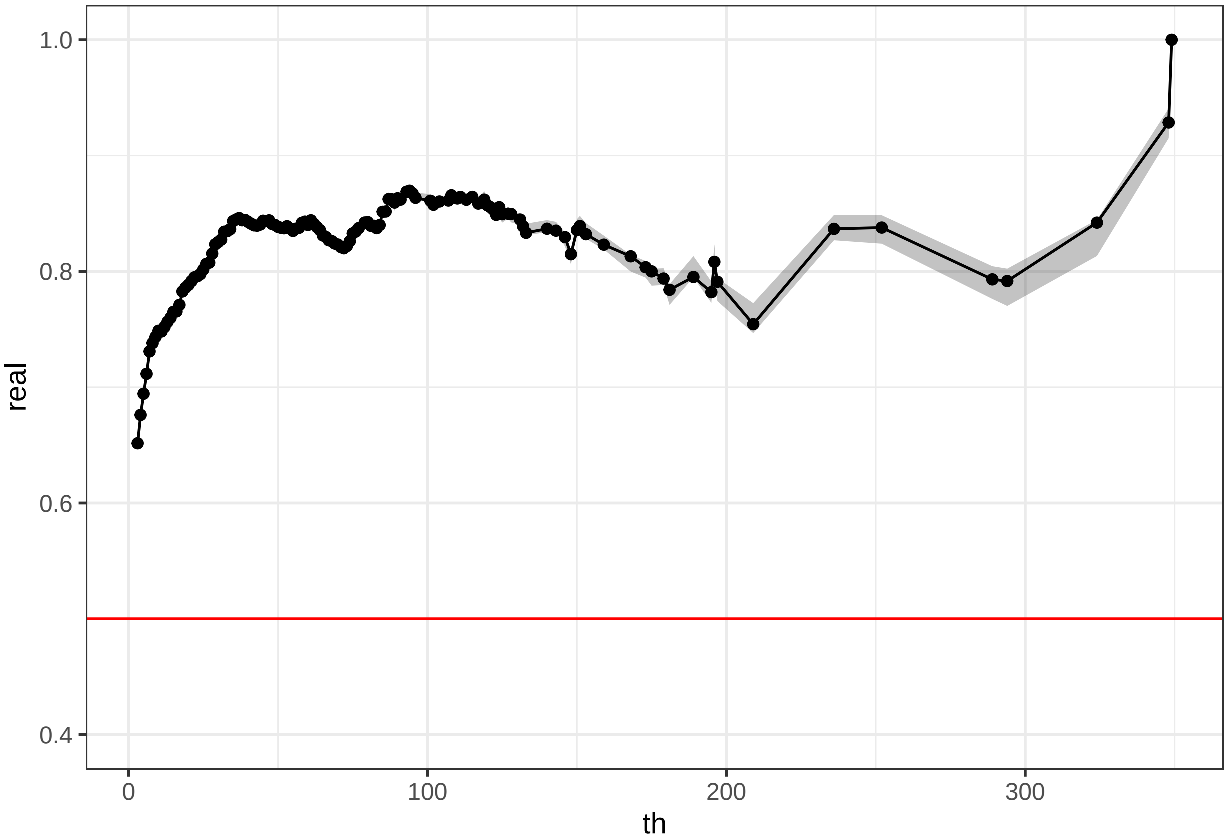


Figure 3 SI - estimation of the threshold for noise in the case of a relaxation of the definition of similarity



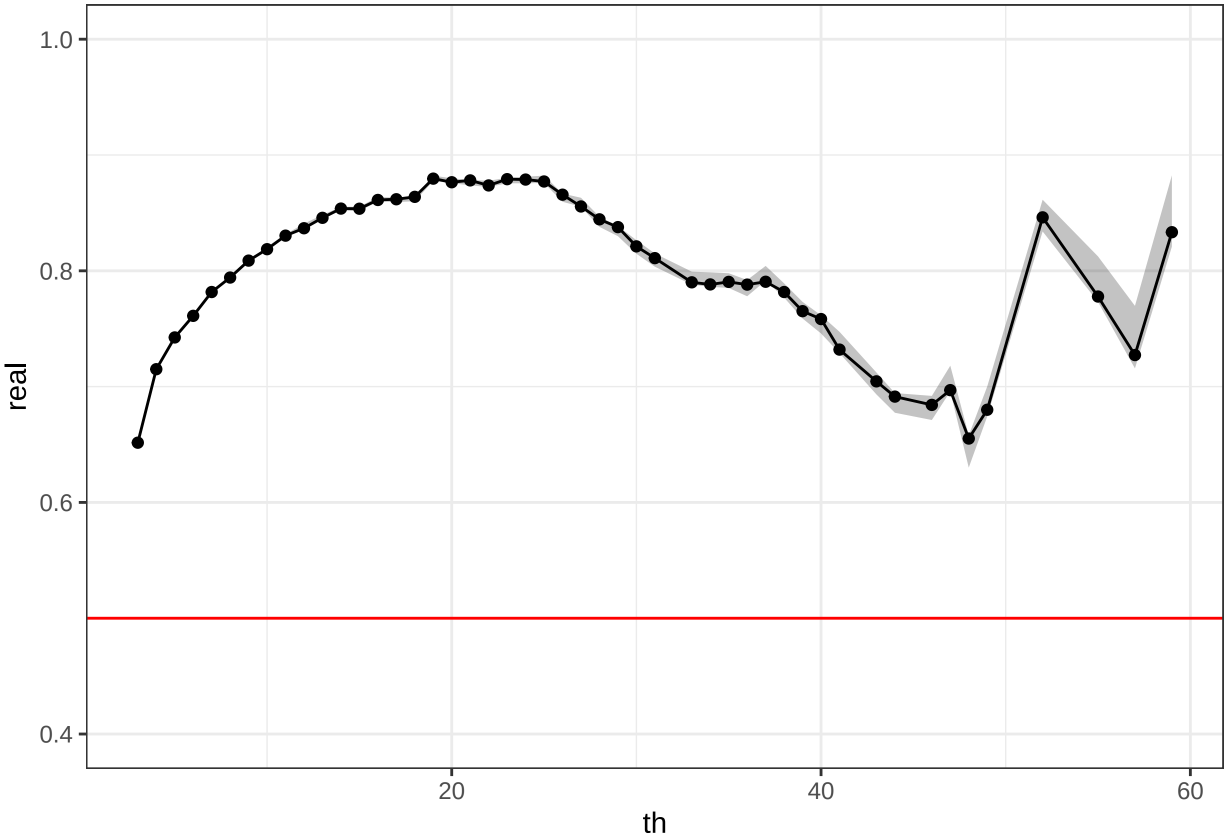


Figure 5 - heatmaps of the MTurk annotations

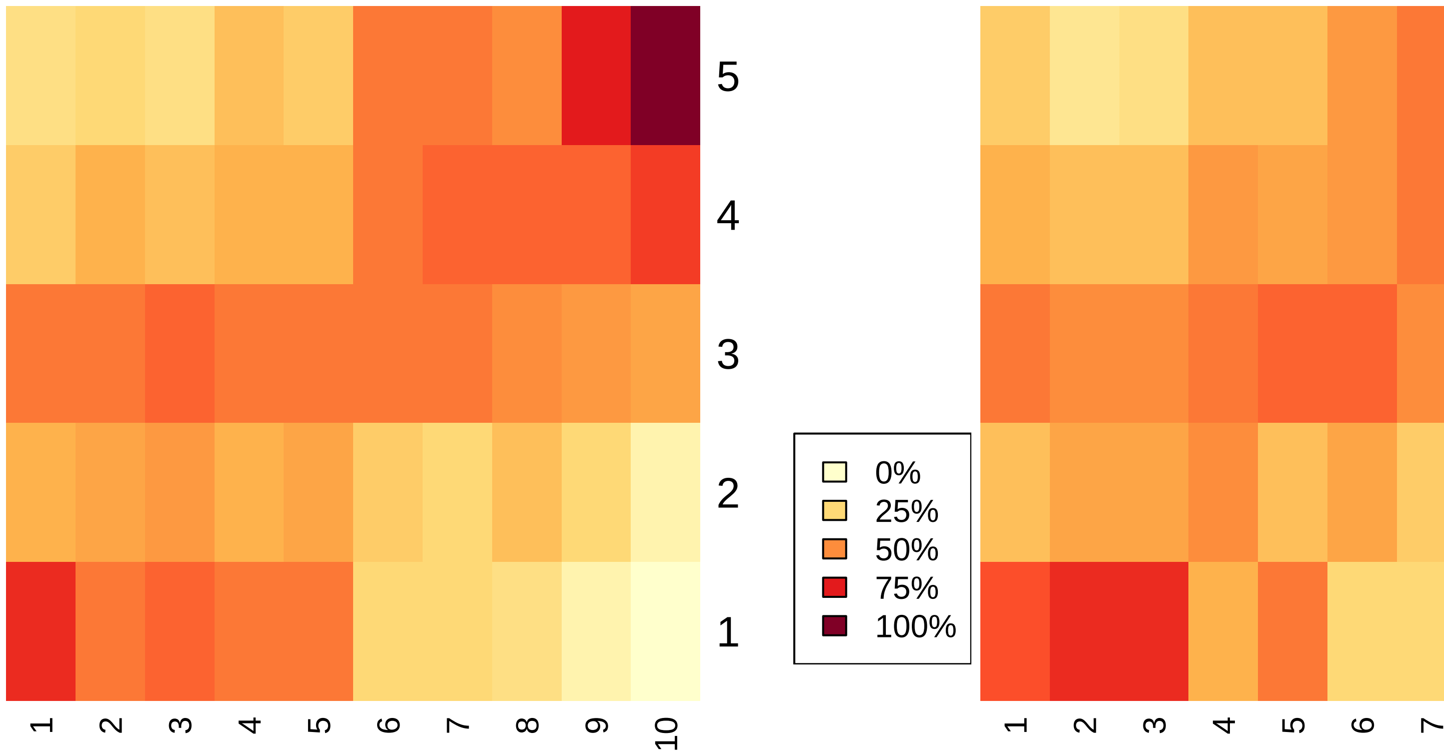
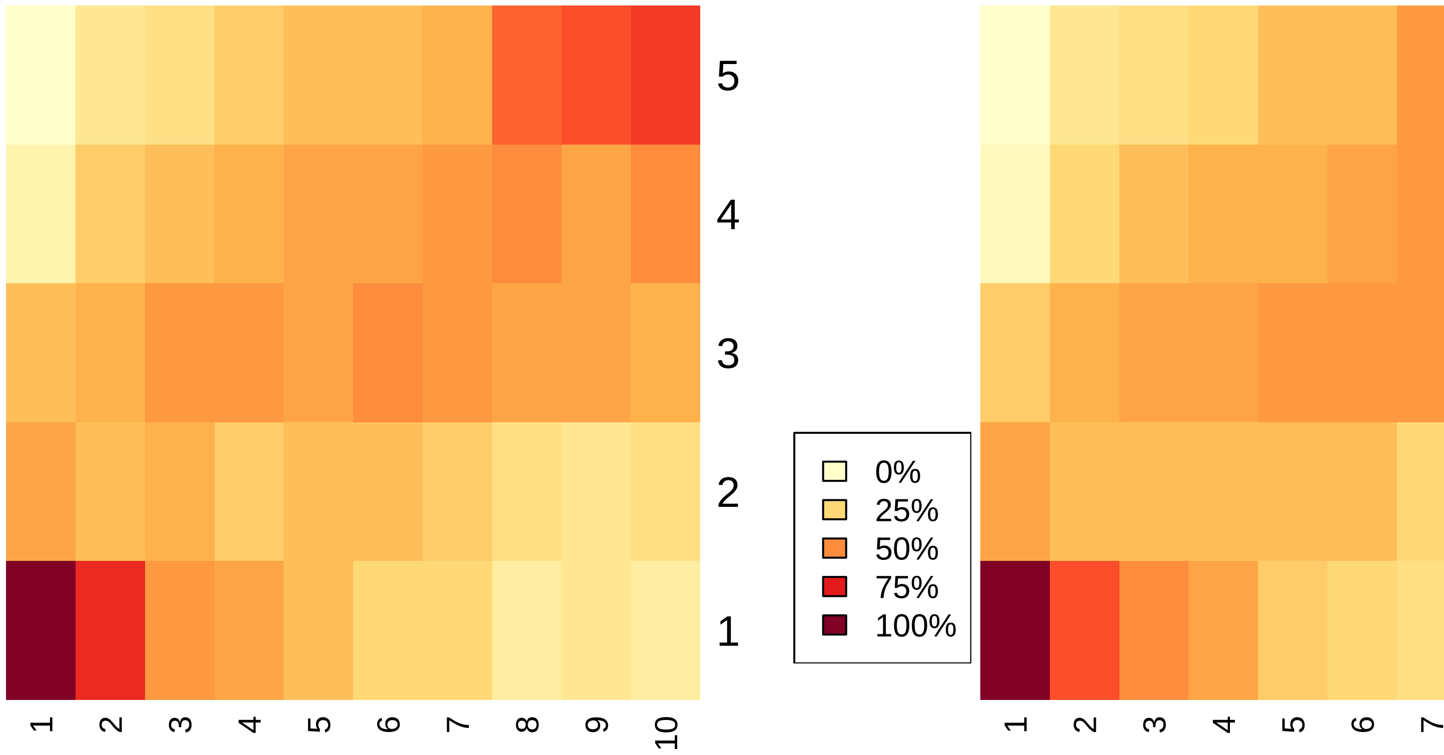


Figure 4 SI - heatmaps with distances


5
4
3
2
1
0%
25%
50%
75%
100%
1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
7