

Supplementary Information for Co-occurrence network of TV advertisements revealing Japanese lifestyle

S.1 Fitting power-law to strength distribution

We fitted a power law $p(s) = (\alpha - 1)s_{\min}^{\alpha-1}s^{-\alpha}$ to the strength distribution $p(s)$ of co-occurrence network for each year. We followed the procedure in Clauset et al [1].

Firstly, we set the lower bound s_{\min} of strength which follows a power law as any strength in the observed data. For s_{\min} and for the observed data of strength s_i , we derived the maximum likelihood estimator $\hat{\alpha}$ of the scaling parameter as

$$\hat{\alpha} = 1 + N \left[\sum_{i=1}^N \ln \frac{s_i}{s_{\min}} \right]^{-1},$$

where N is the number of nodes. We calculated Kormogorov-Smirnov (KS) statistics between the estimated distribution $\hat{p}(s) = (\hat{\alpha} - 1)s_{\min}^{\hat{\alpha}-1}s^{-\hat{\alpha}}$ and the empirical distribution of the strength by only using strength greater than s_{\min} . After varying s_{\min} , we adopted the values of s_{\min} and $\hat{\alpha}$ that correspond to the minimum value of KS statistics.

Subsequently, we tested the goodness of our fitting. We generated 2,500 sets of samples. Each of these samples consists of elements that follow the estimated power-law distribution for values greater than s_{\min} and follow the empirical distribution for the other values. KS statistics can be calculated for each generated set by applying the same procedure as that previously mentioned for the fitting to the observed data, and we can obtain the empirical distribution of KS statistics. The fraction of generated sets that exhibited KS statistics larger than the one of the observed data can be regarded as p -value for the null hypothesis that the observed data obeys a power-law. Table S.1 exhibits the detailed results of the fitting. According to Clauset et al., p -value is needed to be greater than 0.1 to conclude that the observed data obeys a power law [1]. Therefore, co-occurrence networks of TV commercials in 2009, 2013 and 2014 can be regarded as following power laws, while networks for the other years also exhibit a strong heterogeneity in the strength distribution.

Table S.1: Results of fitting. For each year, the minimum value s_{\min} , the proportion of nodes that have the strength greater than s_{\min} , which is complementary cumulative probability $P(> s_{\min})$, KS statistics, the estimated value of α and p -value of a goodness-of-fit test are shown.

Year	s_{\min}	$P(> s_{\min})$	KS	α	p -value
2006	0.17	0.053	0.027	2.17	0.0028
2007	0.14	0.080	0.026	2.10	0.0004
2008	0.19	0.072	0.023	2.13	0.0468
2009	0.27	0.055	0.024	2.14	0.1060
2010	0.42	0.041	0.026	2.16	0.0404
2011	0.28	0.063	0.023	2.13	0.0208
2012	0.05	0.334	0.026	2.01	0.0000
2013	0.50	0.034	0.022	2.24	0.2624
2014	0.48	0.036	0.022	2.23	0.2244
2015	0.10	0.195	0.022	2.15	0.0000
2016	0.48	0.037	0.021	2.21	0.0480
2017	0.12	0.173	0.019	2.12	0.0000
2018	0.15	0.163	0.017	2.08	0.0000
2019	0.75	0.034	0.022	2.16	0.0576
2020	0.24	0.101	0.020	2.10	0.0156

S.2 Community structure

Tables S.2-S.6 show four nodes with the largest strength in the communities that have the first to the seventh largest size for each year.

Table S.2: The size and four nodes with the largest strength in each community from 2006 to 2008.

Year	Size	Nodes with the first to the forth largest strength			
2006	3189	cinema scope	sing	dance	black & white
	2760	woman	walk	eat	inside a store
	2219	animation	run	boy	C.G.
	1325	man	drink	tell	train
	1238	family	married couple	mother	child
	975	logo	white back	black back	small screen
	911	man & woman	rain	cry	kiss
2007	2386	cinema scope	sea	performance	forest
	2114	woman	indoor	photo	PC
	1891	animation	boy	run	C.G.
	1825	man	tell	office	TV
	1762	product	white back	logo	black back
	1716	family	eat	child	mother
	1175	man & woman	walk	city	car
2008	2652	woman	product	drink	tell
	2566	cinema scope	performance	live	night
	2255	animation	run	boy	illustration
	2086	indoor	family	child	eat
	1607	man	sea	bicycle	laugh
	1044	girl	white back	character	logo
	737	dance	rotating	stage	audience

Table S.3: The size and four nodes with the largest strength in each community from 2009 to 2011.

Year	Size	Nodes with the first to the fourth largest strength			
2009	2451	woman	indoor	drink	tell
	2382	cinema scope	aerial view	cherry blossoms	building
	2099	animation	girl	run	boy
	1972	product	white back	small screen	black back
	1775	man	TV	office	phone
	1702	family	eat	child	married couple
	1146	sing	dance	live	performance
2010	2966	woman	tell	indoor	walk
	2375	product	white back	drink	small screen
	2356	cinema scope	TV	poster	CM
	2335	animation	girl	run	boy
	2001	eat	family	child	mother
	1958	man	office	suited man	stairs
	1606	sing	dance	black & white	live
2011	3201	woman	indoor	walk	room
	2409	eat	family	child	married couple
	2390	animation	girl	boy	run
	2021	man	black & white	office	kimono woman
	1567	character	white back	black back	logo
	1528	cinema scope	sea	sky	flower
	1468	sing	dance	dance	performance

Table S.4: The size and four nodes with the largest strength in each community from 2012 to 2014.

Year	Size	Nodes with the first to the fourth largest strength			
2012	3335	animation	cinema scope	girl	run
	2864	woman	indoor	walk	room
	2112	sing	dance	black & white	dance
	1962	product	character	illustration	married couple
	1903	drink	eat	logo	cooking
	1837	man	office	surprise	phone
	1696	family	child	mother	girl
2013	3702	woman	product	indoor	room
	3381	animation	cinema scope	girl	character
	2160	man	black & white	surprise	phone
	1984	family	married couple	child	mother
	1969	city	walk	car	sea
	1741	sing	dance	dance	live
	1563	eat	drink	inside a store	cooking
2014	3848	woman	product	indoor	walk
	3317	animation	cinema scope	character	logo
	2700	family	eat	married couple	mother
	2196	man	office	conversation	phone
	1955	city	sea	flower	surprise
	1787	sing	dance	dance	live
	1214	character	white back	black back	rotating

Table S.5: The size and four nodes with the largest strength in each community from 2015 to 2017.

Year	Size	Nodes with the first to the forth largest strength			
2015	4144	animation	logo	girl	boy
	3394	woman	indoor	walk	smile
	3364	cinema scope	run	city	car
	3226	eat	drink	family	surprise
	3139	product	tell	illustration	studio
	2940	man	office	conversation	laugh
	2363	sing	dance	dance	black & white
2016	6320	woman	product	tell	indoor
	5598	animation	run	girl	boy
	3975	eat	family	married couple	red back
	2795	man	office	laugh	bicycle
	2768	black back	sing	dance	jump
	2458	sea	city	night	sky
	2152	character	logo	white back	blue back
2017	4612	animation	girl	character	game screen
	4569	product	tell	smile	studio
	3934	eat	family	laugh	married couple
	3824	cinema scope	sea	aerial view	night
	3776	logo	white back	character	smartphone
	3573	woman	indoor	walk	office
	2428	dance	sing	white back logo	many people

Table S.6: The size and four nodes with the largest strength in each community from 2018 to 2020.

Year	Size	Nodes with the first to the fourth largest strength			
2018	5369	product	man & woman	drink	pose
	4091	animation	white back logo	girl	character
	3828	eat	family	laugh	parent and child
	3608	logo	white back	telop	jump
	3546	cinema scope	black back	dance	sing
	3450	woman	smile	walk	indoor
	3286	aerial view	sea	car	night
2019	4590	product	indoor	a word	round frame
	4471	cinema scope	aerial view	walk	close-up a face
	4265	black back	animation	white back logo	run
	4143	logo	white back	suited man	rejoice
	3414	man	drink	laugh	surprise
	3087	eat	family	photo	parent and child
	2466	woman	smile	pose	office
2020	3147	cinema scope	black back	white back logo	aerial view
	2627	product	product in hand	round frame	blue back
	2576	man	man & woman	a word	surprise
	2035	logo	character	smartphone	illustration
	1832	animation	girl	character	boy
	1529	white back	room	bed	children
	1418	woman	walk	another woman	step

S.3 Relationship between communities and categories

We show the relationship $w_{l,k}$ between categories and communities that have the first to the tenth-largest size in each year in Figs S.1-S.5.

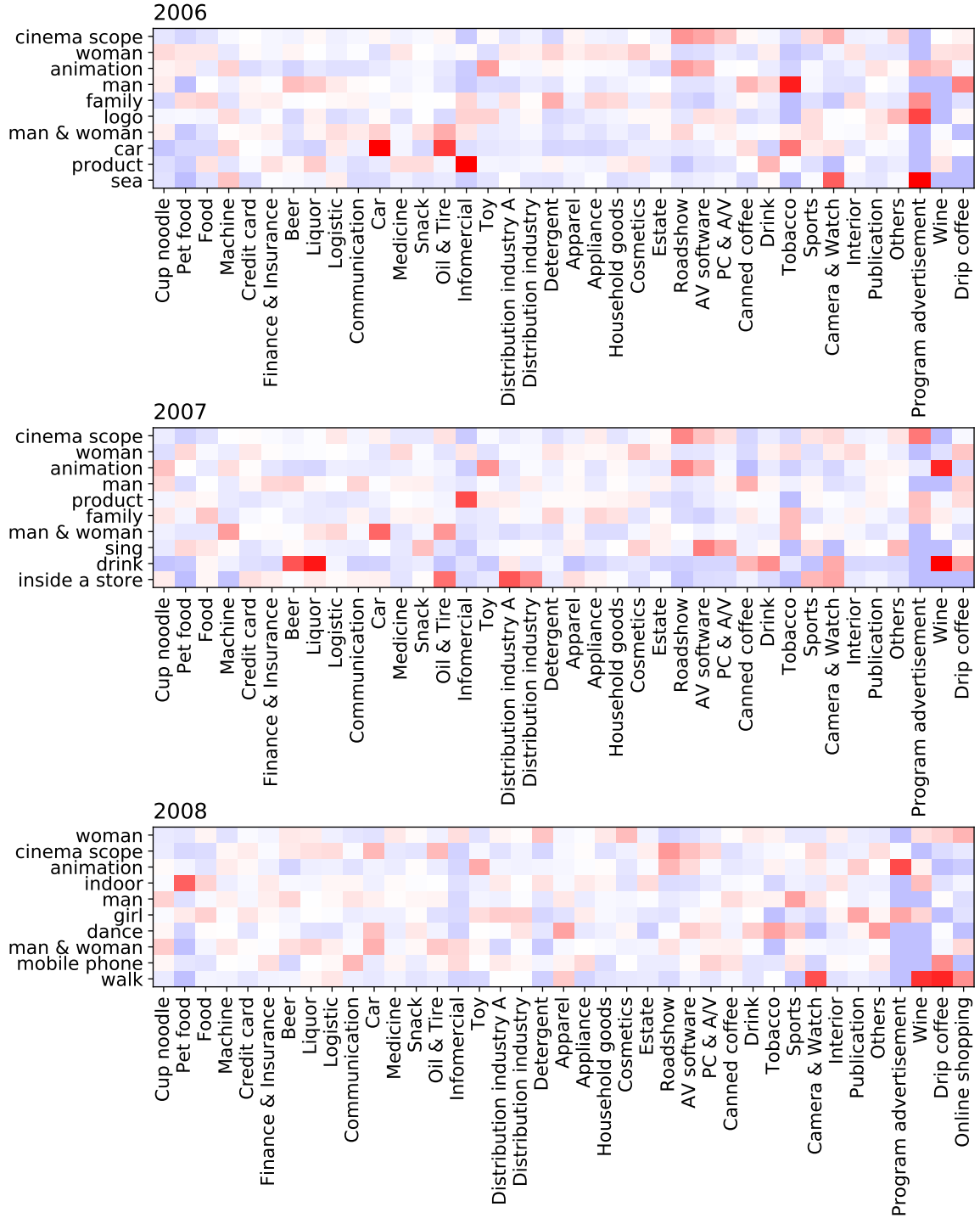


Figure S.1: Relationship $w_{l,k}$ between communities and categories from 2006 to 2008. The horizontal and vertical axes show the categories and the representative nodes in the communities, respectively.

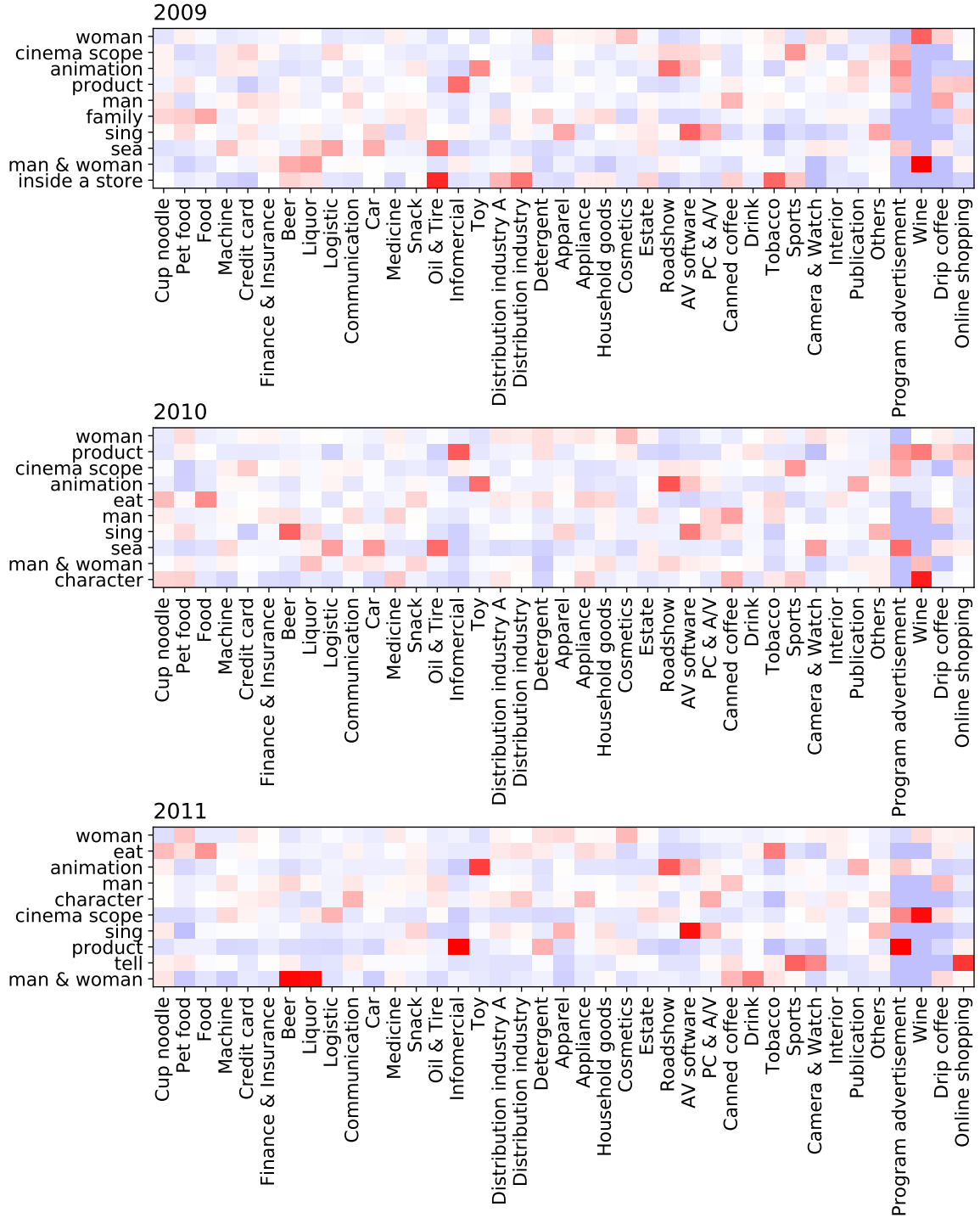


Figure S.2: Relationship $w_{l,k}$ between communities and categories from 2009 to 2011. The horizontal and vertical axes show the categories and the representative nodes in the communities, respectively.

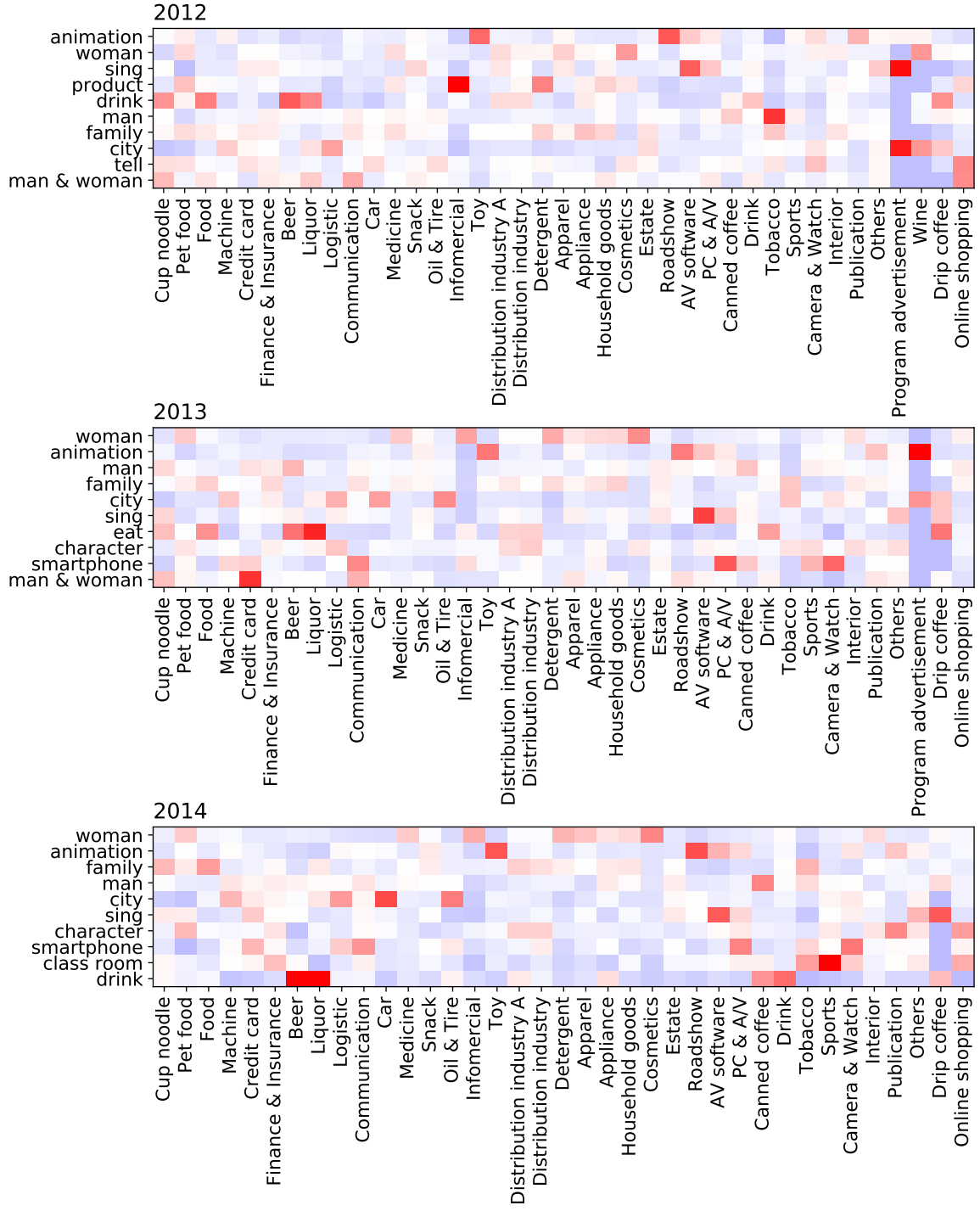


Figure S.3: Relationship $w_{l,k}$ between communities and categories from 2012 to 2014. The horizontal and vertical axes show the categories and the representative nodes in the communities, respectively.

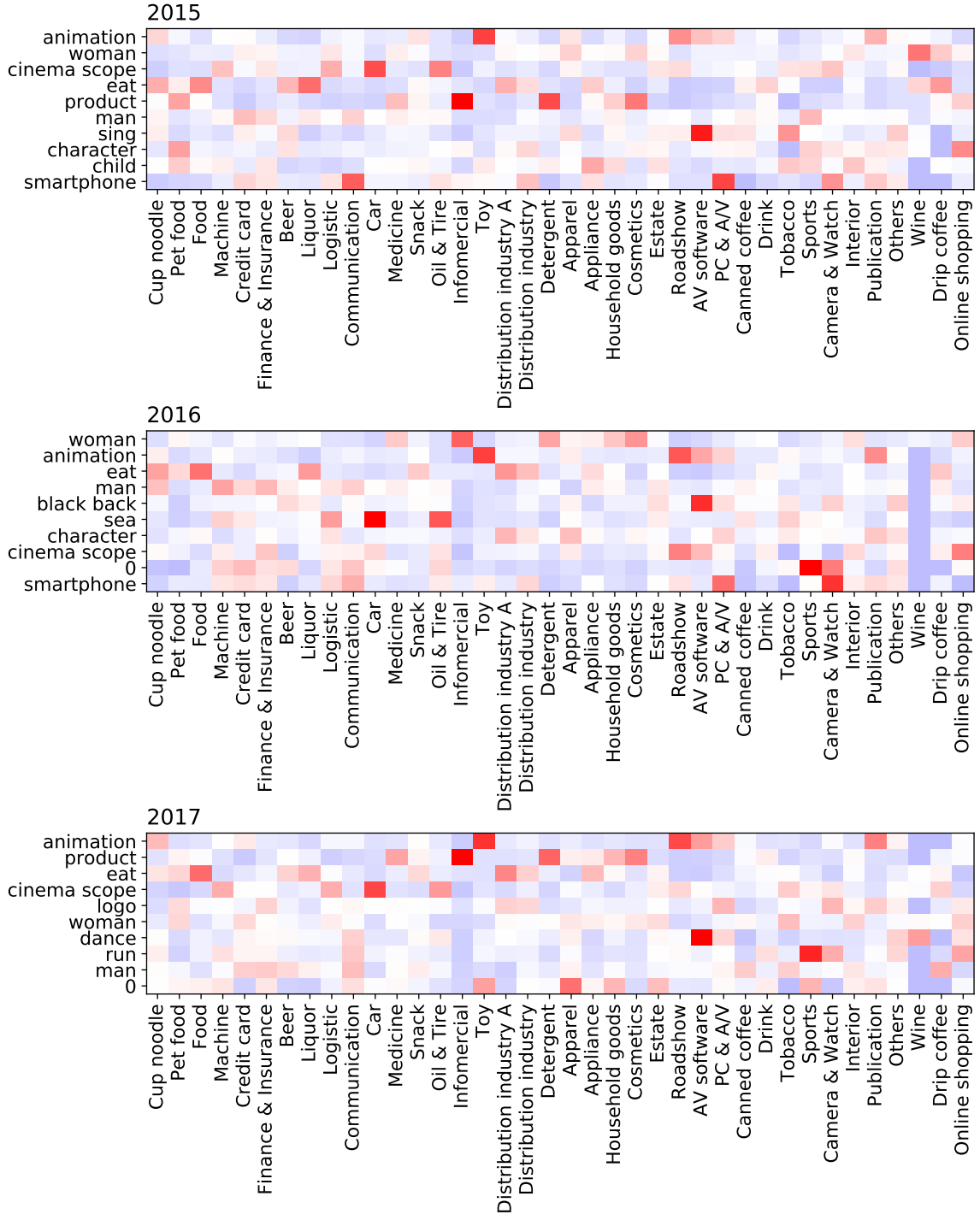


Figure S.4: Relationship $w_{l,k}$ between communities and categories from 2015 to 2017. The horizontal and vertical axes show the categories and the representative nodes in the communities, respectively.

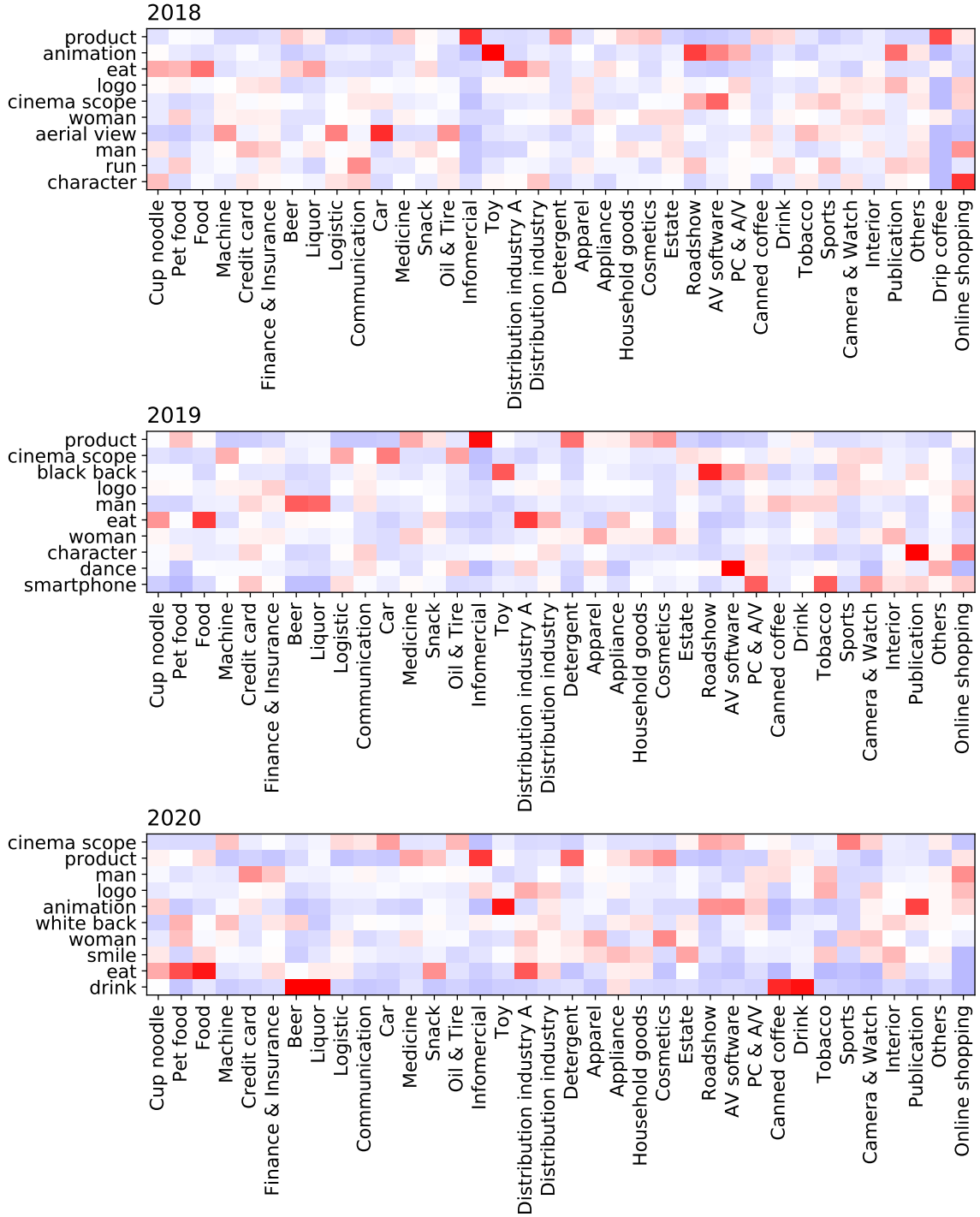


Figure S.5: Relationship $w_{l,k}$ between communities and categories from 2018 to 2020. The horizontal and vertical axes show the categories and the representative nodes in the communities, respectively.

References

- [1] Clauset, A., Shalizi, C.R., Newman, M.E.J.: Power-law distributions in empirical data. *SIAM Rev* **51**(4), 661–703 (2009)