The Influence of Language, Culture, and Environment on the Use of Spatial Referencing in a Multilingual Context: Taiwan as a Test Case—supplemental material

In this document, we provide the spatial descriptions in Taiwanese Min Nan and Mandarin Chinese, more detailed coding for responses for reference frames, linguistic, cultural and environmental variables, and quantitative models building for the statistical results.

1. Spatial descriptions in Taiwanese Min Nan and Mandarin Chinese

The present study focuses on two study languages in Taiwan—Taiwanese Min Nan and Mandarin Chinese. As members of the Sinitic language family, MC and TMN exhibit divergent features in terms of spatial grammar. One crucial difference between MC and TMN is the preference for frame use. As the language with the most native speakers in the world, there is no existing documentation to delineate the use of spatial representations in MC and its preference is assumed to be relative without thorough scholarly examination (Beller et al., 2015). This results in a limited understanding of its structure and the type of relative frames used in the spatial representations. The research presented here documents the availability and preference of spatial descriptions in MC and TMN for the first time, verifying the relative frame preference assumed previous work.

The classification of the spatial descriptions follows the six-way typology from Bohnemeyer et al (2015) for crosslinguistic analyses.

Absolute frames

In the database, this type is absent in MC and the predominant strategy in TMN. TMN speakers use this strategy, by introducing cardinal terms 'east', 'west', 'south' and 'north' to refer to cardinal directions. There are four variants to express the use of the absolute frames in TMN, as seen in (1)[1]: (1a) constitutes a verb meaning *ǹg* 'facing toward' and a cardinal term *tang* 'east'; (1b) consists of a posture predicate *khiā/tsē* 'sit'/'stand', a spatial coverb meaning 'toward' and the cardinal term; (1c) combine a posture predicate *khiā/tsē* 'sit'/'stand' with the cardinal term to express the location, followed by the coverb *ǹg* to express the orientation; (1d) comprises a locative predicate *tī* 'be.at', a cardinal and a region term.

[Taiwanese Min Nan]

(1a)	hit	tsiah	ti-á		ǹg			tang		
	that	CL	pig-DIM	facing toward		east				
(1b)	hit	tsiah	ti-á		khiā/tsē		ǹg			tang
	that	CL	pig-DIM		stand/sit		facing toward			east
(1c)	hit	tsiah	ti-á	tsē	pak	ǹg	tang			
	that	cl	pig-DIM	sit	north	facing	east			
	'That pig is sitting north facing east.'									
(1d)	hit		tsiah	ti-á		tī		tang-pîng		
	That		CL	pig-DIM		LOC		east-side		
	'That pig is at the east.'									

Intrinsic frames

In MC, the activation of intrinsic frames involves the recognition of the geometry of the animals so the four relators, *yò* 'right', *zuǒ* 'left', *qián* 'front' and *òu* 'back' are often recognized as the salient components of the animals. As seen in (2), the right part of the pig is recognized as the salient part by the speaker. The locative construction constitutes a locative predicate *zaì* 'be at' and the reference object *zhū* 'pig' combined with a possessive marker *de*, a spatial relator 'right' and a region term.

[1] A key to the abbreviations used in the interlinear glosses provided: CL—classifier; DIM—Diminutive.

[Mandarin Chinese]

(2)	Nà	zhī	niú	zhàn	zaì	zhū	de	yò	biēn
	that	CL	cow	stand	be.at	pig	POSS	right	side

'That cow is (standing) to the right of the pig.'

In TMN, the intrinsic frames are also frequently used in the spatial descriptions, which involves a locative predicate 'be at', and a composite of a part and a region term. Recall that in TMN, the relators *tsiànn* and *tò* to refer to the left/right axis are derived terms from the part terms 'front' and 'back' respectively (see Section 2.3.2). This language-specific feature prevents the TMN speakers from applying the terms 'left' and 'right' to the left/right axis. As a result, only front and back terms are candidates in this frame type. In TMN, the way to express the front/back region is to form a composite of a body part, e.g., *thâu* 'head' and *bué* 'tail', and region term, e.g., *tsîng* 'front' and *āu* 'back'. As illustrated in (10), the locative predicate, and a composite of a part of an animal and a region term.

[Taiwanese Min Nan]

(3)	tsit	tsiah	ti-á	(khiā)	tī	hit	tsiah	gû
	This	CL	pig-DIM	(stand)	be.at	that	CL	cow

'This pig is (standing) in front of that cow.'

Direct frames

This type occurs in both MC and TMN. There are two variants to express direct frames. One is similar to English by using a pronoun to describe the location and orientation of an object, as seen in (4a) and (4b). The other way is to employ an unbounded reflexive term meaning 'self' in the descriptions as seen in (5b) and (5b). Sometimes the speaker can add a pronoun before the reflexive for the purpose of disambiguation.

[Mandarin Chinese]

(4a)	Zhè	zhī	zhū	khàn	zhe	wǒ/wǒ-men/nǐ	
	This	CL	pig	see	ASP	1SG/1SG-PL/2SG.	
(4b)	Zhè	zhī	zhū	khàn	zhe	(wǒ /wǒ-men/nǐ)	zìjǐ
	This	CL	pig	see	ASP	(1SG/1SG-PL/2SG)	self

'This pig is looking at me/us/you.'

[Taiwanese Min Nan]

(5a)	tsit	tsiah	ti-á	khuànn	guá/lán/lí	
	This	CL	pig-DIM	see	1SG/1SG-INCL/2SG.	
(5b)	tsit	tsiah	ti-á	khuànn	guá/lán/lí	ka-tī
	This	CL	pig	see	1SG/1SG-PL/2SG	self

'This pig is looking at me/us/you.'

Relative frames

This strategy is prevailing in MC but minor in TMN. There are two major differences of the use of relative frames between the two languages. The first difference is regarding the use of the four relators to refer to the left/right and front/back axis respectively. As the dominant strategy, the MC speakers project their perspective freely onto all animal leading to the frequent use of the four spatial relators 'right/left' and 'front/back' to refer to the left/right axis and front/back axis respectively to describe the location and orientation of an object, as seen in (6a) and (6b). These terms can further form a combinatorial pattern, as illustrated in (6c).

(6a)	Nà	zhī	niú	zhàn	zaì	(wǒ de)	zuǒ	(shuǒ)	biēn
	That	CL	cow	stand	be.at		left	(hand)	side

'That cow is standing at (my) left (hand) side.'

(6b)	Nà	zhī	niú	zhàn	zaì	zuǒ	(shuǒ)	biēn
(6c)	Nà	zhī	niú	zhàn	zaì	zuǒ	hòu	fāng

To explore the factors that affect the use of spatial FoRs, the responses were coded for linguistic, cultural and environmental variables. The coding principles are described in detail below. These principles informed the data structure and assisted the variable selection and sample comparison in the statistical analyses.

2 Coding for spatial responses, linguistic, cultural, and environmental variables

2.1 Coding for responses for reference frames in the discourse study

In the discourse study, each trial involves a unique configuration of four animals. Each director's response to each trial was broken down into four descriptions, one per animal, each comprising the total set of propositions produced by the director in response to the trial that treat the particular animal as figure of a locative or orientation representation. Each proposition potentially employs a unique reference frame for its interpretation. Propositions were assigned to the frame type(s) that would make them true of the animals in the trial at issue. In case a proposition was true under multiple frames, it was treated as ambiguous. Ambiguous framing such as the intrinsic/relative ambiguity was treated as a separate response type and not included in this paper. Descriptions were then scored for each frame type instantiated by at least one proposition expressed by them. As seen in Table 3, the relative/egocentric response strategies only included relative/egocentric encoding, the geocentric response strategies included the absolute and externally landmark-based types, and other response strategies included intrinsic, direct and topological types.

2.2 Coding for responses in the recall memory study

Responses were coded for the orientation of the array with the exclusive options of geocentric, egocentric and neither. The neither order was not be part of the analyses since there were no such axis rotation reconstructions, e.g., the speakers arranged animals in contradictory orientation such as one facing south and the rests facing north. If participants performed more than 2 errors, they would be excluded from the experiment. Except that one participant seemed to have serious cognitive difficulty and quit in the middle of the task, all collected data were in use and converted for the statistical analyses.

2.3 Coding for linguistic, cultural and environmental variables

Linguistic variables

To investigate the role of language in the use of spatial FoRs, the current study collected data on a number of linguistic and related variables in the sample comparison that derive from the research questions and associated hypotheses discussed in the introduction. The frequency of first and second language use was included as possible predictors of Linguistic Relativity. The participants self-reported values for these settings using a scale with the levels 'always', 'often', 'occasionally', 'rarely', and either 'never' or 'N/A', from highest to lowest. The responses were converted these categorical responses into a three-point scale: 2—frequent or regular TMN/MC use; 1—occasional TMN/MC use; 0— no TMN/MC use.

Figure 1 shows the number of participants by frequency level of Taiwanese Min Nan (TMN) use for each language population: Mandarin Chinese (TMC) and Taiwanese Min Nan (TMN) monolinguals, sequential bilinguals (TMB) and simultaneous bilinguals (TSB). The frequency of TMN use represents the frequency of use as first language for TMN, TMB and TSB groups in this study. As expected, the two monolingual groups show a clear contrast in frequency of use and the two bilingual varieties display one major difference: the sequential bilinguals spoke TMN more frequently than the simultaneous bilinguals by having 82% frequent speakers. The simultaneous bilinguals were more evenly distributed in terms of frequency of TMN use.

Figure 1. The distribution of frequency of TMN use by language population

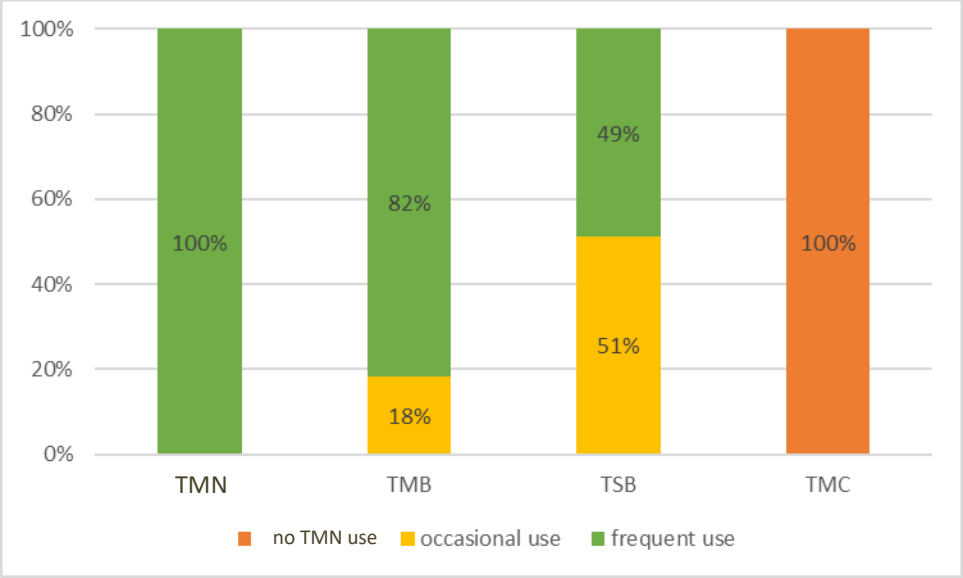
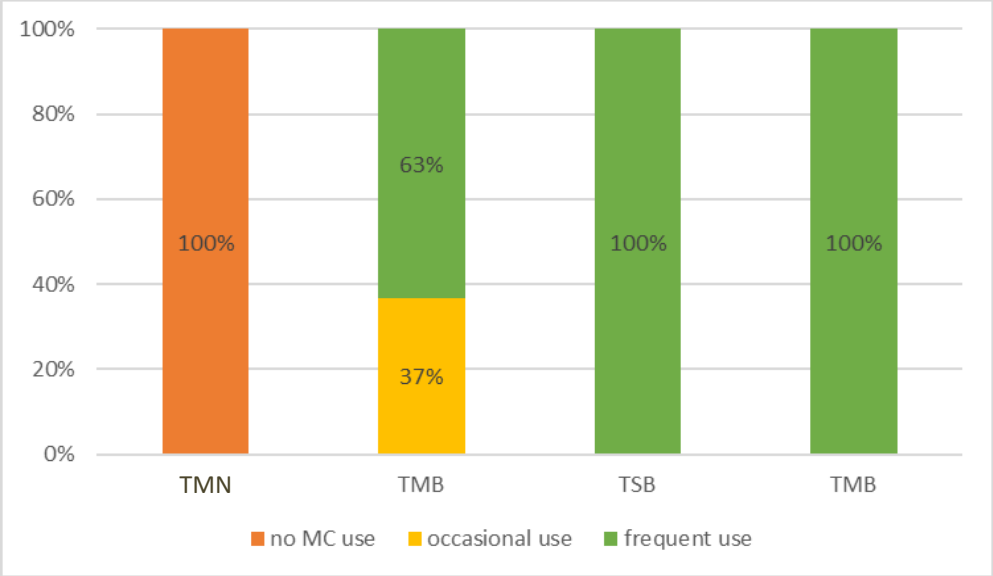


Figure 2 presents the distribution of frequency of MC use by language population. The frequency of MC use represents the combination of first (for the TMC and TSB groups) and second language use (for the TMB group). As expected, the monolingual populations exhibit a contrast in terms of frequency of MC use. Between the two bilingual varieties, a more drastic difference emerged: the distribution of frequency of MC use found in the simultaneous bilinguals resembles the pattern found in the MC monolinguals.

Figure 2. The distribution of frequency of MC use by language population

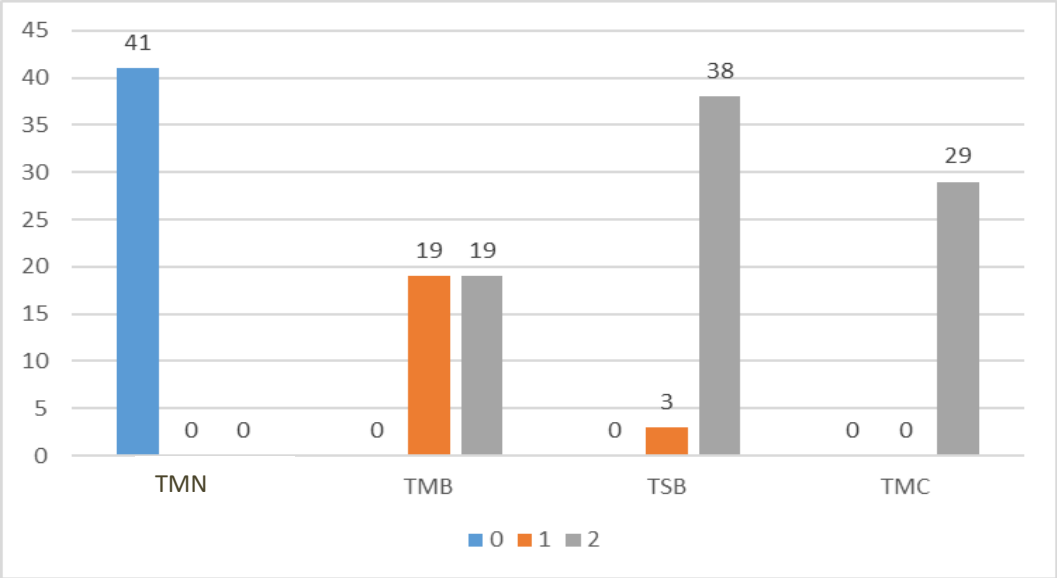


Cultural variables

The cultural variables of education and literacy were included in the present study to investigate whether they affect the use of spatial FoRs in the Taiwanese populations. As discussed in Section 2.2.3, education may boost the use of relative frame types but in some case, the preferred frame type may depend on the type of education system. As for education level, participants were asked how many years of schooling they completed and which level of educational institution they attended: elementary, secondary and college levels. Values were assigned as follows: 0 for participants having only attended elementary school; 1 for participants who received any amount of secondary education; 2 for participants who received any amount of

postsecondary education. The participants were also asked to evaluate their frequency of reading and writing in separate questions using a four-level scale, assigned with values 0-3, 3= regularly; 2 = occasionally; 1= rarely; 0 = I don't. As shown in Figure 3, the distribution of participants by education level varied drastically between language populations: the TMN monolinguals showed mostly low levels of formal education, whereas the MC monolinguals were all highly educated. Between the bilingual populations, sequential bilinguals (TMB) had a more even distribution and simultaneous bilinguals (TSB), like MC monolinguals, were highly educated. This distribution reflects the language ecology and policy in Taiwan as discussed in Section 2.3.2.

Figure 3. Number of participants by education level and language population



In terms of literacy, as manifested by daily reading frequency in the self-reported data in Figure 4, there is a drastic difference between the two monolingual populations. TMN monolinguals mostly reported reading never or rarely, while MC monolinguals all reported the highest level of reading frequency. The two bilingual varieties appear to be identical to each other.

Figure 4. Number of participants by daily reading frequency and language population

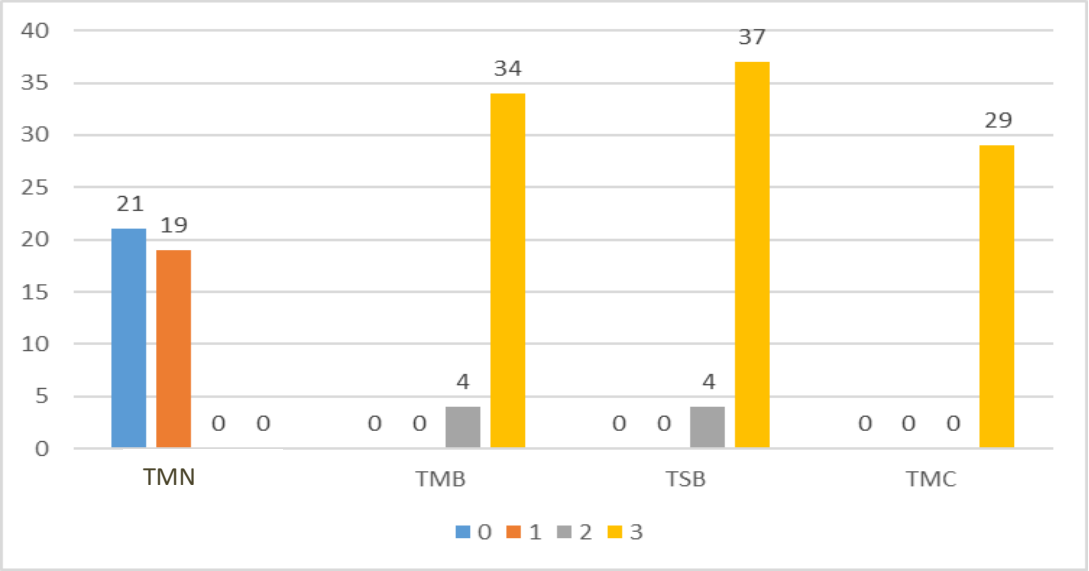
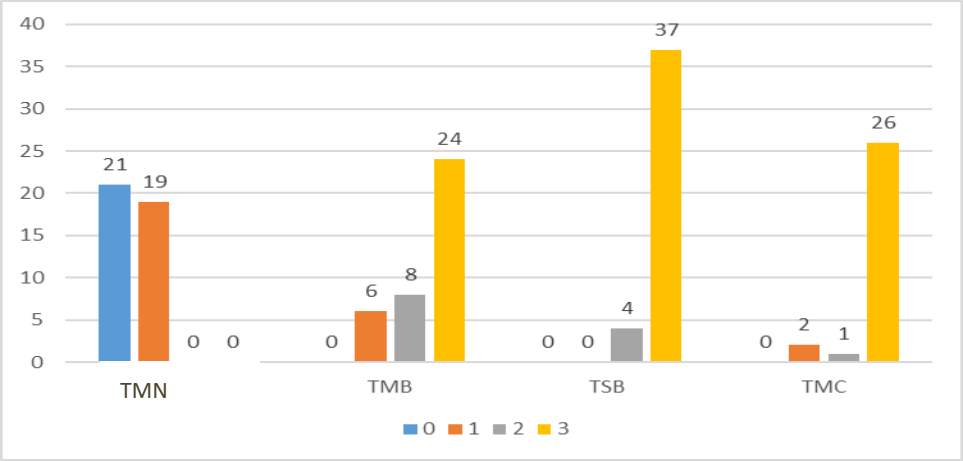


Figure 5 presents the distribution of daily writing frequency across populations. TMN monolinguals show a drastic difference to the other language populations, writing rarely or never. The other three language populations show a relatively higher level of writing.

Figure 5. Number of participants by daily WRITING frequency and language population



Environmental variables

To explore the research question regarding the influence of the environment on the use of spatial FoRs, two types of environmental variables were included as possible predictors of FoR preference: local topography. The topographic profiles of the field sites were classified based on the Improved Hammond classification. Geomorphological data for this classification was obtained through the ArcGIS Online database (www.arcgis.com), developed by Environmental Systems Research Institute (ESRI 2011).

Table 1 lists topographic information, and number of participants of each field site. The majority of the participants came from the northern and southern parts of Taiwan, though some were included from central Taiwan to explore questions of areal differences. Based on the search results from the ESRI map, the landforms of Taichung and Keelung are classified as hills and rest as flat areas.

Table 1. Geomorphological classification of location and population density for each field site and number of participants collected

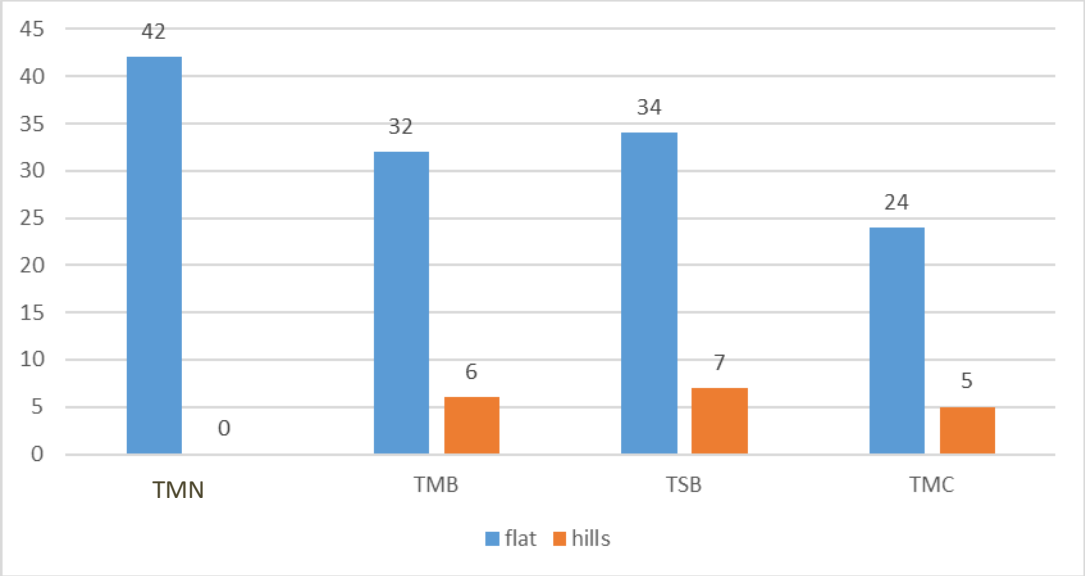
	City	Topographic classifications	Number of participants
Northern	Keelung	Hills	2
	Taipei	Flat Areas	48
Central	Taichung	Hills	17
Southern	Tainan	Flat Areas	80
	Kaohsiung	Flat Areas	2

Figure 6 presents the distribution of the number of participants collected from each field site. This figure confirms the distributional properties of the language populations in Taiwan: TMN monolinguals mostly reside in southern Taiwan while the MC monolinguals reside in the northern part, and bilinguals are found in between. Note that the sequential speakers (TMB) are more likely to be found in the southern part since their formation requires the parents or major caregiver to be a TMN monolingual.

Since the majority of the geographic areas in Western Taiwan are mostly flat and are the places where the target language populations reside, the majority of these participants unsurprisingly, reside in flat areas

and 20 speakers reside in the hills. One drawback for this unbalanced distribution is that it might affect the statistical results due to a small set of participants collected from the hills. However, by recruiting participants of all language groups from a geographically constant area, the current study can better observe the language contact situation of the area.

Figure 6. Number of participants by topographic profile and language population



3 Variable selection and data analyses

In the Bohnemeyer et al (2014, 2015) papers, a Multidimentional Scale (MDS) analysis showed that relative and geocentric use where the variables that showed the greatest differentiation among participants. Generalized linear mixed effects models (Jaeger, 2008) were implemented using the ARM package in R (Gelman et al., 2012). In order to test which linguistic and nonlinguistic factors contribute to predicting a speaker's use of RELATIVE and GEOCENTRIC frame types, a series of logistic regression analyses were implemented with the probability of a director choosing these frame types as the dependent variables and the relevant predictors mentioned in the Section 3 as independent variables.

The abbreviation for variable is listed as follows: RELT: relative responses, GEOT: geocentric responses, EdD: level of education, MCD: frequency of Mandarin Chinese use, TMND: frequency of Taiwanese Min Nan use, ReadD: frequency of reading, WriteD: frequency of writing, Topo: topography, Lang: language group, and Trial: task trial.

Table 2. The statistical models and its formula across Taiwanese populations in the discourse study

Discourse Study: Fitted models and Formula in the R	
Model 1	glmer(data=TAdata4, formula=RELT~EdD+MCD+TMND+ReadD+Topo+(1|Lang)+(1|Trial), family = "binomial") > summary(TA1) Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod] Family: binomial (logit) Formula: RELT ~ EdD + MCD + TMND + ReadD + Topo + (1 | Lang) + (1 | Trial) Data: TAdata4

	AIC BIC logLik deviance df.resid 1752.7 1795.2 -868.4 1736.7 1482 Scaled residuals: Min 1Q Median 3Q Max -1.1749 -0.8305 -0.3026 0.9081 3.3051 Random effects: Groups Name Variance Std.Dev. Trial (Intercept) 1.594e-10 1.263e-05 Lang (Intercept) 1.022e+00 1.011e+00 Number of obs: 1490, groups: Trial, 4; Lang, 3 Fixed effects: Estimate Std. Error z value Pr(>|z|) (Intercept) -3.50608 0.91668 -3.825 0.000131 *** EdD 0.56409 0.19107 2.952 0.003155 ** MCD 0.72894 0.23468 3.106 0.001896 ** TMND -0.15648 0.16206 -0.966 0.334256 ReadD 0.65537 0.22356 2.932 0.003373 ** Topohills -0.03777 0.17238 -0.219 0.826551 --- Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 Correlation of Fixed Effects: (Intr) EdD MCD TMND ReadD EdD -0.183 MCD -0.443 -0.223 TMND -0.362 0.107 0.255 ReadD -0.600 -0.050 0.221 0.062 Topohills -0.034 -0.004 -0.075 0.230 -0.019
Model 2	glmer(data=TAdata4, formula=RELT~EdD*MCD+TMND+WriteD+Topo+(1|Lang)+(1|Trial), family = "binomial") > summary(TA2) Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod] Family: binomial (logit) Formula: RELT ~ EdD * MCD + TMND + WriteD + Topo + (1 | Lang) + (1 | Trial) Data: TAdata4 AIC BIC logLik deviance df.resid 1754.3 1802.1 -868.1 1736.3 1481 Scaled residuals: Min 1Q Median 3Q Max -1.1899 -0.9390 -0.3529 0.9180 2.8334 Random effects: Groups Name Variance Std.Dev. Trial (Intercept) 0 0 Lang (Intercept) 0 0

	Number of obs: 1490, groups: Trial, 4; Lang, 3 Fixed effects: Estimate Std. Error z value Pr(>|z|) (Intercept) -1.72967 0.23564 -7.340 2.13e-13 *** EdD 0.17901 0.29816 0.600 0.5482 MCD 0.21757 0.23566 0.923 0.3559 TMND -0.17664 0.08518 -2.074 0.0381 * WriteD 0.11005 0.11221 0.981 0.3267 Topohills -0.04112 0.16855 -0.244 0.8073 EdD:MCD 0.23850 0.17336 1.376 0.1689 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 Correlation of Fixed Effects: (Intr) EdD MCD TMND WriteD Tphlls EdD -0.053 MCD -0.093 0.166 TMND -0.718 -0.131 -0.056 WriteD -0.220 -0.282 -0.519 -0.006 Topohills -0.050 0.066 -0.017 0.091 -0.058 EdD:MCD -0.042 -0.822 -0.558 0.275 0.215 -0.061
Model 3	glmer(data=TAdata4, formula=GEOT~EdD+MCD+TMND+ReadD+Topo+(1|Lang)+(1|Trial), family = "binomial") > summary(TA3) Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod] Family: binomial (logit) Formula: GEOT ~ EdD + MCD + TMND + ReadD + Topo + (1 | Lang) + (1 | Trial) Data: TAdata4 AIC BIC logLik deviance df.resid 1256.3 1298.8 -620.2 1240.3 1482 Scaled residuals: Min 1Q Median 3Q Max -1.5910 -0.3171 -0.2105 0.7070 5.6001 Random effects: Groups Name Variance Std.Dev. Trial (Intercept) 0.000 0.000 Lang (Intercept) 5.579 2.362 Number of obs: 1490, groups: Trial, 4; Lang, 3 Fixed effects: Estimate Std. Error z value Pr(>|z|) (Intercept) 1.6217 1.5449 1.050 0.293833 EdD -1.0842 0.2274 -4.767 1.87e-06 *** MCD -1.4865 0.2329 -6.382 1.75e-10 *** TMND 1.1486 0.3141 3.657 0.000255 ***

	ReadD -0.6550 0.1737 -3.770 0.000163 *** Topohills 0.7778 0.2962 2.626 0.008641 ** --- Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 Correlation of Fixed Effects: (Intr) EdD MCD TMND ReadD EdD -0.134 MCD -0.241 -0.223 TMND -0.334 0.113 0.216 ReadD -0.259 -0.113 0.185 0.028 Topohills -0.064 -0.016 -0.159 0.317 -0.059
Model 4	glmer(data=TAdata4, formula=GEOT~EdD+MCD+TMND+WriteD+Topo+(1|Lang)+(1|Trial), family = "binomial") > summary(TA4) Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod] Family: binomial (logit) Formula: GEOT ~ EdD + MCD + TMND + WriteD + Topo + (1 | Lang) + (1 | Trial) Data: TAdata4 AIC BIC logLik deviance df.resid 1270.5 1312.9 -627.2 1254.5 1482 Scaled residuals: Min 1Q Median 3Q Max -1.2054 -0.3352 -0.2103 0.8296 5.3538 Random effects: Groups Name Variance Std.Dev. Trial (Intercept) 0.000 0.00 Lang (Intercept) 2.592 1.61 Number of obs: 1490, groups: Trial, 4; Lang, 3 Fixed effects: Estimate Std. Error z value Pr(>|z|) (Intercept) 0.154510 1.112905 0.139 0.88958 EdD -1.176886 0.227028 -5.184 2.17e-07 *** MCD -1.340346 0.239160 -5.604 2.09e-08 *** TMND 1.169386 0.308499 3.791 0.00015 *** WriteD -0.005991 0.125037 -0.048 0.96178 Topohills 0.711661 0.295283 2.410 0.01595 * --- Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 Correlation of Fixed Effects: (Intr) EdD MCD TMND WriteD EdD -0.193 MCD -0.217 -0.166 TMND -0.441 0.070 0.179

	WriteD -0.135 -0.125 -0.293 0.056 Topohills -0.104 -0.030 -0.163 0.305 0.041

Table 3. The statistical models and its formula across Taiwanese populations in the recall memory study

Recall Memory Study: Fitted models and Formula in the R	
Model 5	glmer(data=NAdata5, formula=FGEO~EdD+MCD+TMND+ReadD+Topography+(1|LangT)+(1|Trial), family ="binomial") > summary(M7) Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod] Family: binomial (logit) Formula: FGEO ~ EdD + MCD + TMND + ReadD + Topography + (1 | LangT) + (1 | Trial) Data: NAdata5 AIC BIC logLik deviance df.resid 930.3 966.6 -457.1 914.3 688 Scaled residuals: Min 1Q Median 3Q Max -2.2253 -0.9918 0.6658 0.8447 1.4869 Random effects: Groups Name Variance Std.Dev. Trial (Intercept) 0 0 LangT (Intercept) 0 0 Number of obs: 696, groups: Trial, 6; Lang, 3 Fixed effects: Estimate Std. Error z value Pr(>|z|) (Intercept) -0.2416 0.2999 -0.805 0.420622 EdD -0.7424 0.1819 -4.081 4.48e-05 *** MCD 0.5322 0.1660 3.206 0.001345 ** TMND 0.3885 0.1111 3.496 0.000472 *** ReadD -0.0438 0.1242 -0.353 0.724310 Topographyhills 0.5995 0.2432 2.465 0.013707 * --- Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1 Correlation of Fixed Effects: (Intr) EdD MCD TMND ReadD EdD -0.073 MCD -0.299 -0.383 TMND -0.818 0.085 0.237 ReadD -0.239 -0.446 -0.399 0.052 Tpgrphyhlls 0.054 -0.444 0.412 -0.083 -0.152
Model 6	glmer(data=NAdata5, formula=FGEO~EdD+MCD+TMND+WriteD+Topography+(1|LangT)+(1|Trial), family ="binomial")

```
> summary(M8)
Generalized linear mixed model fit by maximum likelihood
  (Laplace Approximation) [glmerMod]
  Family: binomial    ( logit )
Formula:
FGEO ~ EdD + MCD + TMND + WriteD + Topography + (1 | LangT) +
       (1 | Trial)
     Data: NAdata5

     AIC          BIC     logLik     deviance     df.resid
     930.3       966.7    -457.1       914.3          688

Scaled residuals:
    Min          1Q      Median          3Q         Max
-2.2068     -1.0093     0.6741      0.8462      1.5260

Random effects:
  Groups Name            Variance    Std.Dev.
  Trial    (Intercept)          0           0
  LangT    (Intercept)          0           0
Number of obs: 696, groups:    Trial, 6; Lang, 3

Fixed effects:
                    Estimate     Std. Error    z value      Pr(>|z|)
(Intercept)         -0.27014      0.29154      -0.927       0.354133
EdD                 -0.79440      0.18149      -4.377        1.2e-05 ***
MCD                  0.48941      0.16619      2.945        0.003231 **
TMND                 0.38504      0.11258      3.420        0.000626 ***
WriteD               0.03477      0.11961      0.291        0.771263
Topographyhills      0.58008      0.24149      2.402        0.016304 *
---
Signif. codes:    0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
                (Intr)      EdD       MCD       TMND      WriteD
EdD             -0.169
MCD             -0.389    -0.383
TMND            -0.812     0.182    0.321
WriteD          -0.039    -0.442    -0.403     -0.167
Tpgrphyhlls      0.023    -0.477    0.389      -0.061     -0.090
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References

Beller, S., K. Brattebø, K. Lavik, R. Reigstad & A. Bender. 2015. Culture or language: What drives effects of grammatical gender? *Cognitive Linguistics* 26(2). 1–29.

Bohnemeyer, J., K. T. Donelson, R. E. Moore, E. Benedicto, A. Eggleston, C. K. O’Meara, G. Pérez Báez, E. Palancar, G. Polian & R. Romero Méndez. 2015. The contact diffusion of linguistic practices. *Language Dynamics and Change* 5(2). 169–201.

Bohnemeyer, J., K. T. Donelson, R. Tucker, E. Benedicto, A. Capistrán Garza, A. Eggleston, N. Hernández Green, M. Hernández Gómez, S. Herrera Castro, C. K. O’Meara, E. Palancar, G. Pérez Báez, G. Polian & R. Romero Méndez. 2014. The cultural transmission of spatial cognition: Evidence from a large-scale study. In P. Bello, M. Guarini, M. McShane & B. Scassellati (eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society*. 212-217. Austin, TX: Cognitive Science Society.

Jaeger, T. F. 2008. Categorical data analysis: Away from ANOVAs (transformation or not) and towards Logit Mixed Models. *Journal of Memory and Language* 59. 434–446.
ESRI (2011). ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.