Experimental research on role effect of mathematic examples learning

CCNU

Yang Lei 杨磊

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1. Introduction

Learning is facilitated by interaction with conversational agents that employ effective pedagogical strategies in Intelligent Tutoring Systems (ITS).

One-on-one tutoring system (one tutor and one human learner) have been shown to be effective in multiple learning domains by various research groups. Recently, multiple agents in ITS are increasingly common.

1. Introduction

Pedagogical agents, vicarious learning presenters, peer agents, affectively supportive agents are common types of roles that agents can play in a tutoring system.

The interactive mechanism between these mulitiple angents ,for example ,who said what in a given situation, and it's impact on learning outcome are still unknown.

1. Introduction

Multinomial processing tree (MPT) models :

MPT models introduced by Riefer and Batchelder (1988)

"Who said what?" (WSW) paradigm:

WSW introduced by Taylor, Fiske, Etcoff, and Ruderman (1978)

Modified "Who said what?"(MWSW) paradigm=MPT+ WSW:

A multinomial model of the "Who said what?" paradigm introduced by Klauer and Wegener in 1998

1. Introduction

The ‘‘Who said what?’’ paradigm is frequently used to measure processes of social categorization which is central to impression formation.

Multinomial processing tree models can be used to to disentangle the relative contributions of the different cognitive processes.

Sex, academic status and other variables have been proven to be important factors in the process.

1. Introduction

In ‘‘Who said what?’’ experiment, participants observe a discussion between members of two or more categories.

In subsequent recognition tests, they are again shown the discussion statements and are then asked to assign each statement to its speaker.

Participant assignment errors can be classified into within-category errors and between-categories errors.

1. Introduction

In the extended version, new items or distracters are also presented in the recogniton test, and participants should decide whether or not the statement occurred in the discussion.

If participants judge the statement old, he or she is required to assign the statement to a speaker in a second step.

1. Introduction

This small modification provides a richer data base, allowing one to disentangle the relative contributions of the different cognitive processes by means of multinomial processing tree models of source discrimination.

In these models, many underlying cognitive processes can be assessed by different parameters, for example, item discrimination, guessing of item status, person memory, person guessing, category memory, reconstructive category guessing and so forth.

1. introduction

Traditional analysis:

Error: error-difference measure

- **within-category errors**
- **between-categories errors**

An important rationale (social categorization):

- **within-group differences are minimized and between-group differences are exaggerated, leading one to expect that the strength of categorization process is reflected in the differential likelihood of confusions within versus between categories.**

K. C. Klauer and I. Wegener, Unraveling social categorization in the "Who said What?" paradigm, 1998

1. Introduction

Conventional Approach:

the difference of within-category and between-categories errors as dependent variable, or equivalently conducted analyses of variance (ANOVAs).

The error-difference measure have easy three confounded processes:

a) **Item discriminations**

b) **Person discriminations**

c) **Category discriminations**

d) **Expectancy-base guessing**

The objective of MWSW paradigm is to propose and validate a substantive model of the processes involved in the "Who said what?" paradigm, that aims at disentangling the separate contributions of these different process.

2. Model, method and result

2.1 theory hypothesis

Hypothesis：

Memory (parameter):

statements by the teacher saying are easier to remember than by students

statements with script present are easier to remember than with random present.

Guessing (parameter) (don't verify in the present)

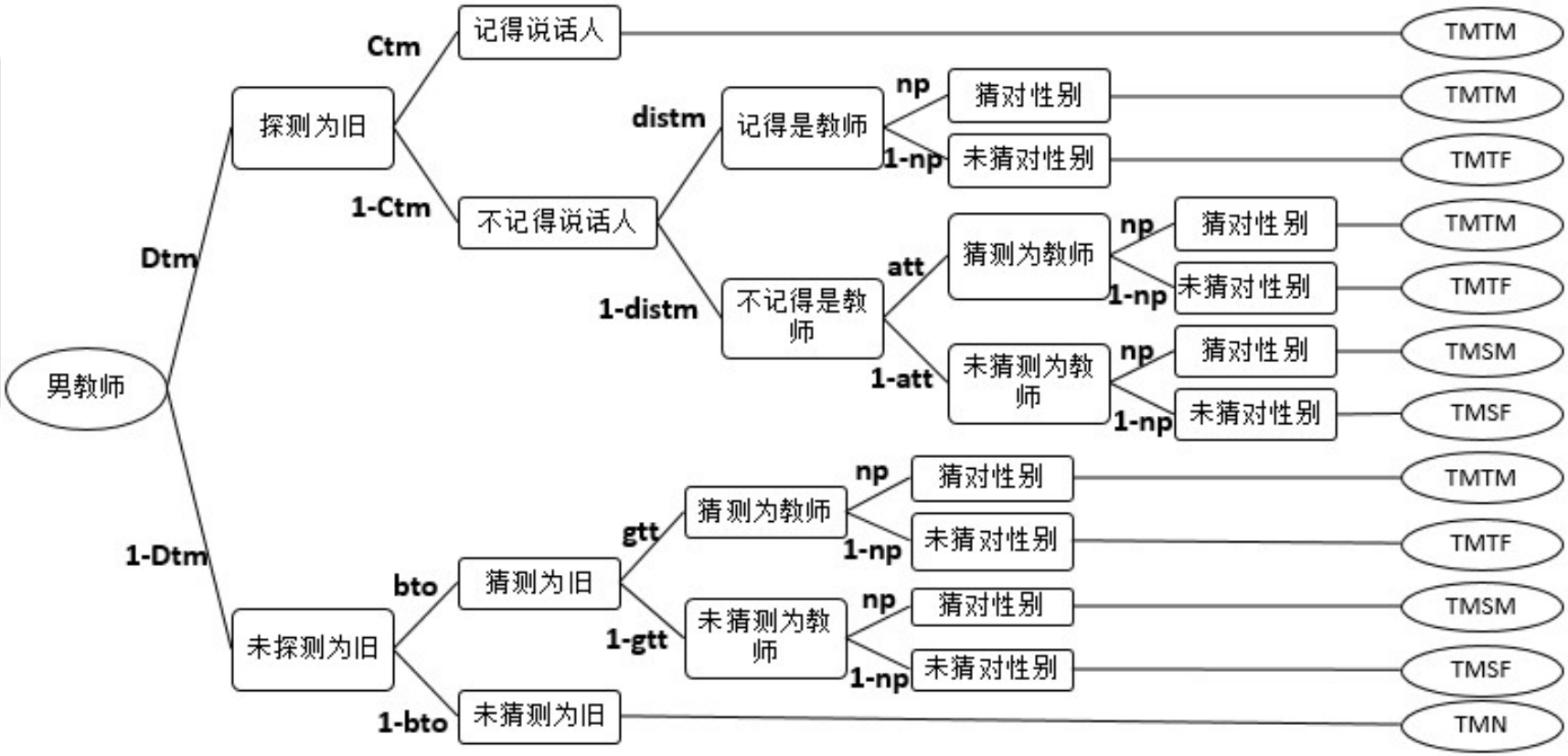
positive examples tends to guess by teacher

negative examples is more likely to guess by students

2. Model, method and result

2.2 Model and Data Matrix

Statements made by the male teacher (TM) category



7 parameters: *Dtm, ctm, distm, att, bto, gtt, np;*

5 observe categories: *TMTM, TMTF, TMSM, TMSF, TMN;*

2. Model, method and result

2.2 Model and Data Matrix

Multinomial processing tree model (*Riefer & Batehelder 1988, Hu & Batchelder 1994, etc***) describes participants' responses by means of the processes of item discrimination, person discrimination, and category discrimination as well as three guessing processes.**

The MWSW modified model has:

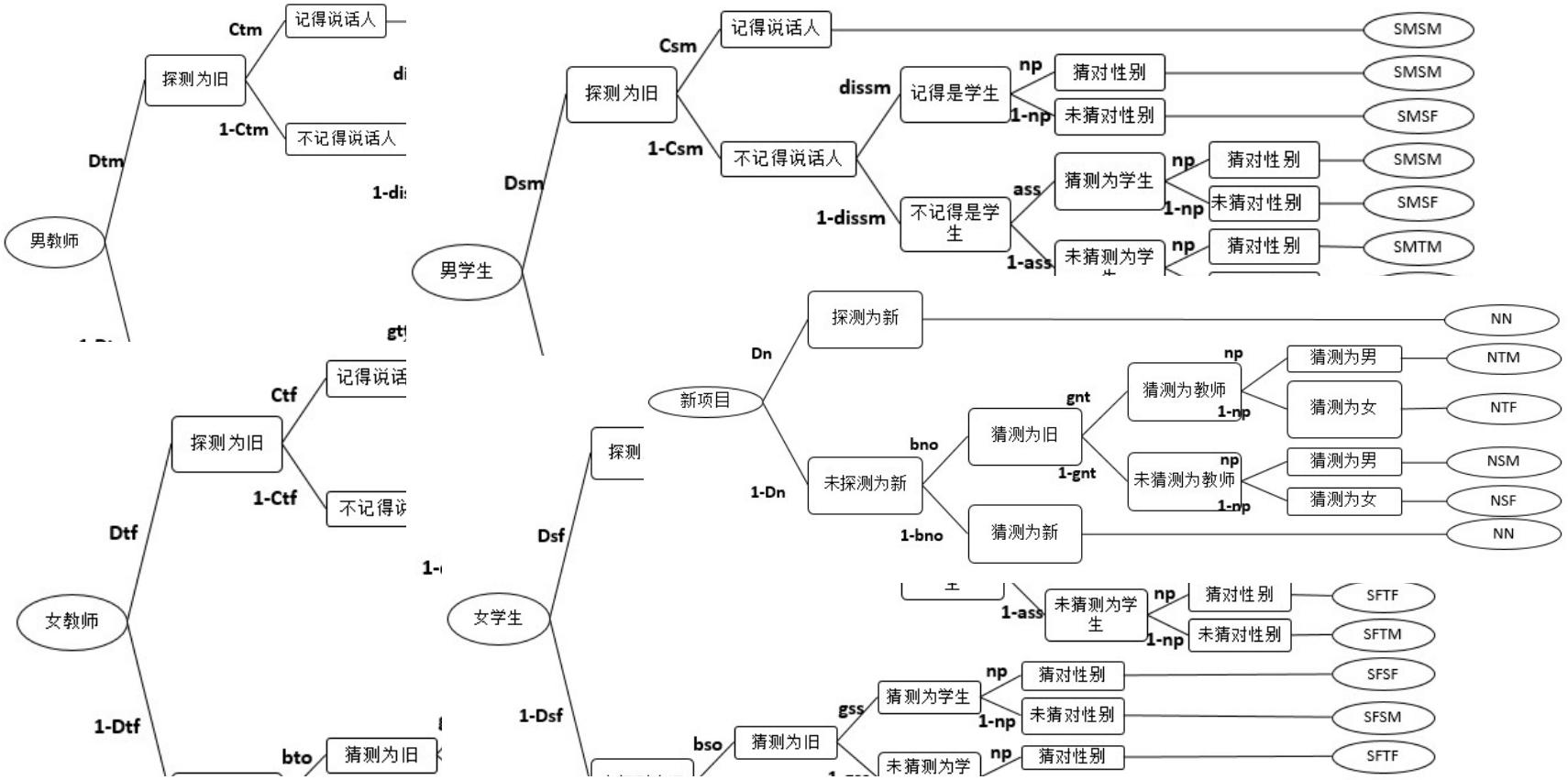
5 trees (*sources category: male teacher, female teacher; male student, female student; new item/ distracter* **)**

25 observed categories (*TMTM, TMTF, TMSM, TMSF, TMN; TFTM, TFTF, TFSM, TFSF, TFN; SMTM, SMTF, SMSM, SMSF, SMN; SFTM, SFTF, SFSM, SFSF, SFN; NTM, NTF, NSM, NSF, NN* **)**

22 parameters (*ass, att, bno, bso, bto, csf, csm, ctf, ctm, dissf, dissm, distf, distm, Dsf, Dsm, Dtf, Dtm, Dn, gnt, gss, gtt, np* **)**

2. Model, method and result

2.2 Model and Data Matrix



5 trees (*sources category: male teacher, female teacher; male student, female student; new item/ distracter*)

2. Model, method and result

2.2 Model and Data Matrix

22 parameters (*ass, att, bno, bso, bto, csf, csm, ctf, ctm, dissf, dissm, distf, distm, Dsf, Dsm, Dtf, Dtm, Dn, gnt, gss, gtt, np* **)**

memory parameters:

Dsf, Dsm, Dtf, Dtm, Dn (Item discrimination)

csf, csm, ctf, ctm (Person discrimination)

dissf, dissm, distf, distm (Category discrimination)

Guessing parameters:

ass, att, gnt, gss, gtt; np

Bias parameters:

bno, bso, bto

2. Model, method and result

2.2 Model and Data Matrix

Sources		Response				
		TM	TF	SM	SF	N
		ChenTao	WangFang	ZhangMing	LiLei	New
TM	ChenTao	**TMTM**	TMTF	TMSM	TMSF	TMN
TF	WangFang	TFTM	**TFTF**	TFSM	TFSF	TFN
SM	ZhangMing	SMTM	SMTF	**SMSM**	SMSF	SMN
SF	LiLei	SFTM	SFTF	SFSM	**SFSF**	SFN
N	New	NTM	NTF	NSM	NSF	**NN**

Note: **T: Teacher; S: Student; M: Male; F: Female; N: New Item/Distracter**
***Means : TMSF*: the statement from the Male Teacher was assigned to the wrong speaker as a Female Student.**

2. Model, method and result

2.2 Model and Data Matrix

within-category errors

between-categories errors

correct

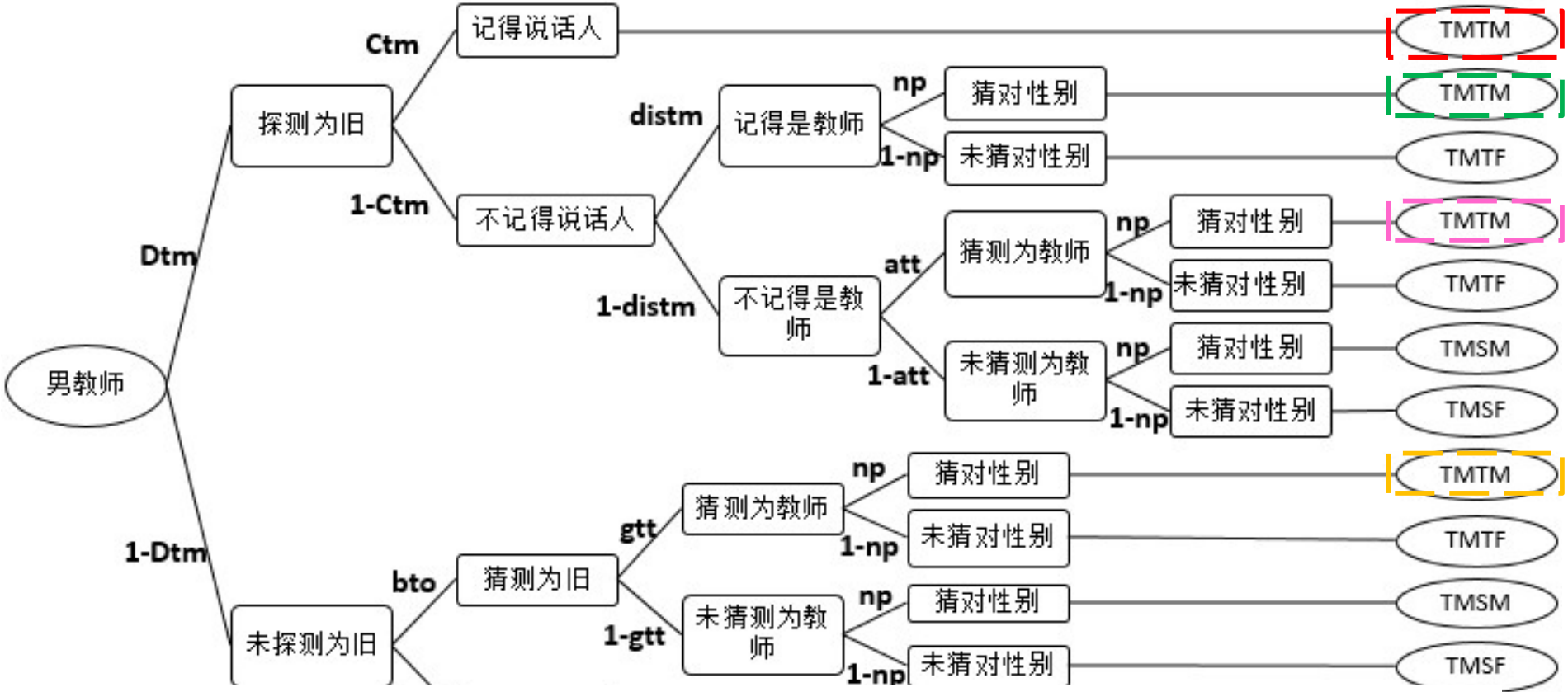
		Response				
		TM	TF	SM	SF	N
Sources		ChenTao	WangFang	ZhangMing	LiLei	New
TM	ChenTao	**TMTM**	TMTF	TMSM	TMSF	TMN
TF	WangFang	TFTM	**TFTF**	TFSM	TFSF	TFN
SM	ZhangMing	SMTM	SMTF	**SMSM**	SMSF	SMN
SF	LiLei	SFTM	SFTF	SFSM	**SFSF**	SFN
N	New	NTM	NTF	NSM	NSF	**NN**

Note: **T: Teacher; S: Student; M: Male; F: Female; N: New Item/Distracter**

***Means : TMSF*: the statement from the Male Teacher was assigned to the wrong speaker as a Female Student.**

2. Model, method and result

2.2 Model and Data Matrix



$$Pr\{TMTM\} = Dtm*ctm + Dtm*(1-ctm)*distm*np + Dtm*(1-ctm)*(1-distm)*a*np + (1-Dtm)*bto*gtt*np$$

2. Model, method and result

2.2 Model and Data Matrix

Source: Male Teacher (TM) 5 equations

$Pr\{TMN\} = (1-D)*(1-b)$

$Pr\{TMSF\} = D*(1-ct)*(1-dist)*(1-a)*(1-np) + (1-D)*b*(1-a)*(1-np)$

$Pr\{TMSM\} = D*(1-ct)*(1-dist)*(1-a)*np + (1-D)*b*(1-a)*np$

$Pr\{TMTF\} = D*(1-ct)*dist*(1-np) + D*(1-ct)*(1-dist)*a*(1-np) + (1-D)*b*a*(1-np)$

$Pr\{TMTM\} = D*ct + D*(1-ct)*dist*np + D*(1-ct)*(1-dist)*a*np + (1-D)*b*a*np$

Source: Female Teacher (TF), Male Student (SM), Female Student (SF),

Each source has 5 equations

Total 25 equations /observe categories

2. Model, method and result

2.2 Model and Data Matrix

the degree of freedom:

df= NOC- NOT - (NOP-NOPCP)

NOC = # of Observed categories

NOT = # of Trees

NOP = # of Parameters

NOPCP = # of Parameters Set as Constant Probability

The degree of freedom of the MWSW model:

df= NOC- NOT - (NOP-NOPCP)=25 - 5 - (22 - 0) = -2

Unrecognized model

Constraint parameter (e.g.:*D=Dsf=Dsm=Dtf=Dtm=Dn, a=ass=att=gnt=gss=gtt, b=bno=bso=bto, cs=csf=csm, ct=ctf=ctm, diss=dissf= dissm, dist=distf=distm, np=0.5* **)**

2. Model, method and result

2.3 Method

Participants:

62 male and female students from the science and technology college.

Pool of statements:

The 48 examples, including 8 knowledge points of elementary mathematic, with each point containing 6 examples which consist of 3 positive examples and 3 negative examples, thus, are made up of 24 positive examples and 24 negative examples.

Study phase: Six knowledge points which include 2 positive and negative examples were random selected from 8 knowledge points.

Test phase: total 48 examples were randomly presented.

(old: 12 positive and 12 negative examples; 24 new items)

2. Model, method and result

2.3 Method

Examples:

剧本三：方程的定义

定义：含有未知数的等式叫做方程。请举例说明。

正例：x+8=12 是方程，因为它是等式且含有未知数。

正例：3x+10=28 是方程，因为它是等式且含有未知数。

正例：2x+5=4x−10 是方程，因为它是等式且含有未知数。

反例：4x−6＞10 不是方程，因为它不是等式。

反例：20−4=16 不是方程，因为它不含未知数。

反例：4+8＞10 不是方程，因为它不是等式且不含未知数。

Randomly presented 2 of the 3.

2. Model, method and result

2.3 Method

Roles:

male teacher, female teacher, male student, female student

2. Model, method and result

2.3 Method

Procedure: *study phase and test phase*

study phase

学习阶段

张明 同学

随机分配可以确保数据呈正态分布。

test phase

新旧判断

随机分配可以确保数据呈正态分布。

呈现过　　未呈现过

人物选择

随机分配可以确保数据呈正态分布。

王芳 老师

陈涛 老师

李蕾 同学

张明 同学

2. Model, method and result

2.3 Method

Experiments:

Experiment 1: Examples were presented at random.

Experiment 2: Examples were presented at script.

Random: *Twelve positive and 12 negative examples are presented randomly.*

Script: *Six knowledge points are presented randomly one by one, and each knowledge point present randomly 2 positive and 2 negative examples.*

To evaluate the role effect of virtual agents, two experiments, in which learning content was presented in random and organized way separately were done.

2. Model, method and result

2.4 Results

Data matrix of experiments:

Experiment 1:

Random present

Sources		Response					
		TM ChenTao	TF WangFang	SM ZhangMing	SF LiLei	N New	Total
TM	ChenTao	**68**	30	21	23	50	192
TF	WangFang	41	**62**	10	15	64	192
SM	ZhangMing	14	26	**56**	27	69	192
SF	LiLei	22	15	31	**60**	64	192
N	New	60	82	58	53	**515**	768
	Total	205	215	176	178	762	1536

Experiment 2:

Script present

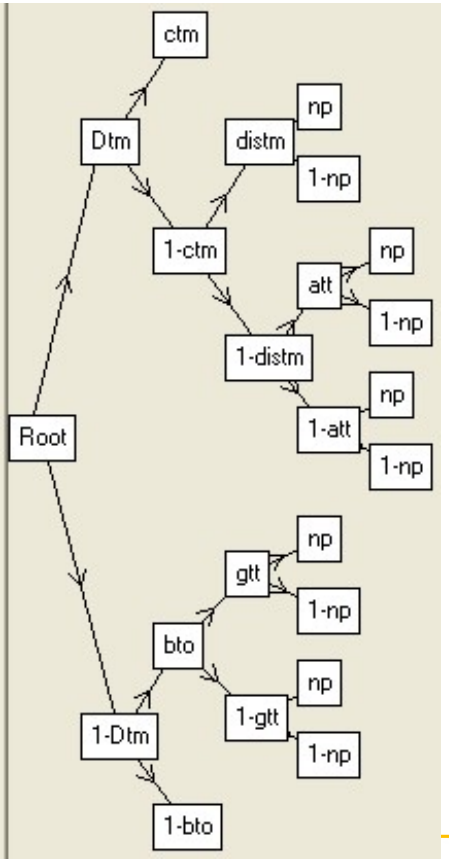
Sources		Response					
		TM ChenTao	TF WangFang	SM ZhangMing	SF LiLei	N New	Total
TM	ChenTao	**86**	18	18	10	60	192
TF	WangFang	17	**83**	15	26	51	192
SM	ZhangMing	26	21	**74**	20	51	192
SF	LiLei	11	19	24	**73**	65	192
N	New	48	41	34	32	**613**	768
	Total	188	182	165	161	840	1536

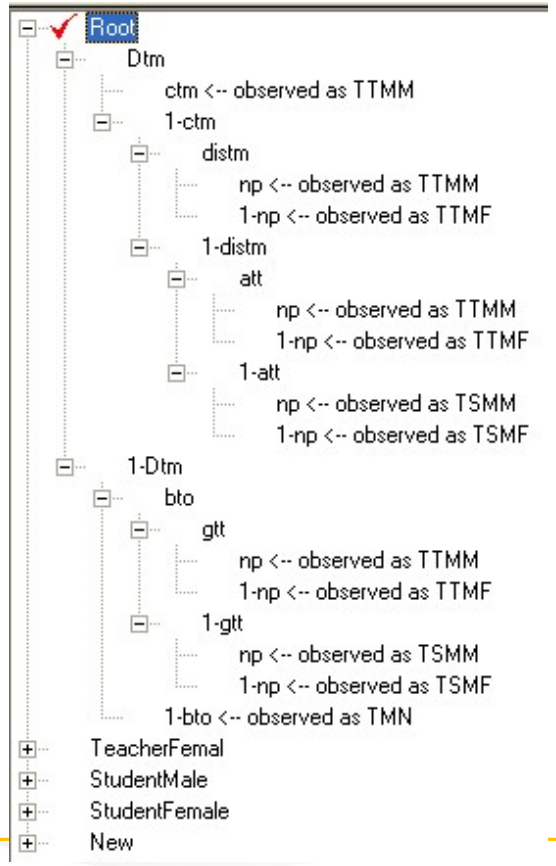
2. Model, method and result

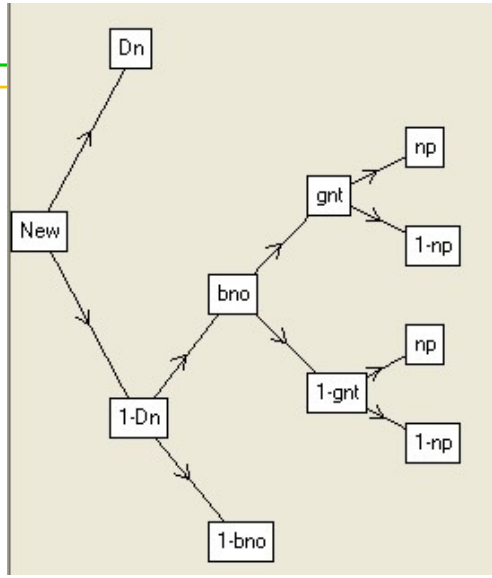
2.4 Results

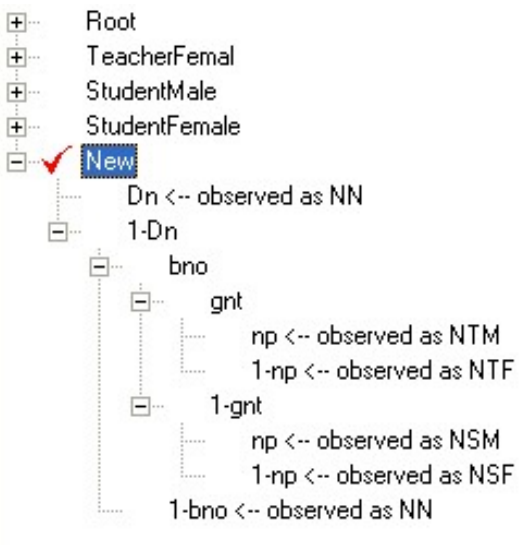
Data analysis software:

GPT , MPTinR









2. Model, method and result

2.4 Results

For the model analyses, we assumed to constraint conditions.

Constraint parameter : (e.g.)

D=Dsf=Dsm=Dtf=Dtm=Dn, item discrimination parameter

a=ass=att=gnt=gss=gtt, probability of guessing category

b=bno=bso=bto, probability of guessing a statement is old

*cs=csf=csm, person discrimination parameter of students**

*ct=ctf=ctm, person discrimination parameter of teachers**

diss=dissf= dissm, category discrimination parameter of students

dist=distf=distm, category discrimination parameter of teachers

2. Model, method and result

2.4 Results

Data set name: Random

Parameter estimates

```
        a =    0.56126, SD =    0.03120, (initial value:    0.78023)
        b =    0.50600, SD =    0.01836, (initial value:    0.13214)
       cs =    0.44922, SD =    0.10110, (initial value:    0.86654)
       ct =    0.42481, SD =    0.10138, (initial value:    0.89625)
        D =    0.34896, SD =    0.02391, (initial value:    0.59970)
     diss =    0.24602, SD =    0.30360, (initial value:    0.67991)
     dist =    0.67257, SD =    0.25500, (initial value:    0.80058)
      np* =    0.50000, Fixed as constant
Test will be a Chi-square with 13 degrees of freedom
Chi-square[13]=  21.62049.
```

an satisfied goodness of fit (G2 = 21.62, df = 13, p =.062)

```
Data set name: Random
-+-+-+-+-+-+-+-+-+-+-+-+-+-
Memo33
-+-+-+-+-+-+-+-+-+-+-+-+-+-
  Category,    Observed,    Expected
        NN,  515.00000,  515.00000
       NSF,   58.00000,   55.50000
       NSM,   53.00000,   55.50000
       NTF,   82.00000,   71.00000
       NTM,   60.00000,   71.00000
       TMN,   50.00000,   61.75000
      TSMF,   23.00000,   16.64306
      TSMM,   21.00000,   16.64306
      TTMF,   30.00000,   34.25093
      TTMM,   68.00000,   62.71296
       SFN,   64.00000,   61.75000
      SSFF,   60.00000,   60.19522
      SSFM,   31.00000,   30.09761
      STFF,   15.00000,   19.97859
      STFM,   22.00000,   19.97859
       SMN,   69.00000,   61.75000
      SSMF,   27.00000,   30.09761
      SSMM,   56.00000,   60.19522
      STMF,   26.00000,   19.97859
      STMM,   14.00000,   19.97859
       TFN,   64.00000,   61.75000
      TSFF,   15.00000,   16.64306
      TSFM,   10.00000,   16.64306
      TTFF,   62.00000,   62.71296
      TTFM,   41.00000,   34.25093
```

2. Model, method and result

2.4 Results

Data set name: Script

Parameter estimates

a =	0.54295,	SD =	0.02566,	(initial value:	0.16662)
b =	0.40576,	SD =	0.01952,	(initial value:	0.13656)
cs =	0.53296,	SD =	0.06167,	(initial value:	0.85159)
ct =	0.66867,	SD =	0.05928,	(initial value:	0.20136)
D =	0.50260,	SD =	0.01382,	(initial value:	0.25760)
diss =	0.00000,	SD =	0.00000,	(initial value:	0.75156)
dist =	0.00000,	SD =	0.01382,	(initial value:	0.04194)
np* =	0.50000, Fixed as constant				

Test will be a Chi-square with 13 degrees of freedom

Chi-square[13]= 19.13377.

an satisfied goodness of fit (G2 = 19.13, df = 13, p =0.12)

Data set name: Script

Memo34

Category,	Ovserved,	Expected
NN,	613.00000,	613.00000
NSF,	34.00000,	35.42147
NSM,	32.00000,	35.42147
NTF,	41.00000,	42.07853
NTM,	48.00000,	42.07853
TMN,	60.00000,	56.75000
TSMF,	10.00000,	16.16211
TSMM,	18.00000,	16.16211
TTMF,	18.00000,	19.19959
TTMM,	86.00000,	83.72619
SFN,	65.00000,	56.75000
SSFF,	73.00000,	74.18563
SSFM,	24.00000,	22.75474
STFF,	19.00000,	19.15481
STFM,	11.00000,	19.15481
SMN,	51.00000,	56.75000
SSMF,	20.00000,	22.75474
SSMM,	74.00000,	74.18563
STMF,	21.00000,	19.15481
STMM,	26.00000,	19.15481
TFN,	51.00000,	56.75000
TSFF,	26.00000,	16.16211
TSFM,	15.00000,	16.16211
TTFF,	83.00000,	83.72619
TTFM,	17.00000,	19.19959

2. Model, method and result

2.4 Results

Parameter	Random			Script		
	Estimate	CI		Estimate	CI	
a	0.56	0.53	- 0.59	0.54	0.52	- 0.57
b	0.51	0.49	- 0.52	0.41	0.39	- 0.43
cs	0.45	0.44	- 0.46	0.53	0.47	- 0.59
ct	0.42	0.32	- 0.53	0.67	0.61	- 0.73
D	0.35	0.33	- 0.37	0.50	0.49	- 0.52
diss	0.25	-0.06	- 0.55	0.00	0.00	- 0.00
dist	0.67	0.42	- 0.93	0.00	-0.01	- 0.01

As can be seen, person discrimination *ct/cs* for teachers /students speakers were much increased in the group with Script.
Item discrimination parameter *D* was increased too.
But the categorization parameters *diss/dist* are not significantly larger than zero.

3. Future works

At present, the experiment is only to simulate the AutoTutor system in E-Prime, and positive and negative examples data were overall analyzed.

The next step will be to do experiments on the SKO (Shareable Knowledge Objects) with middle school students. The data of positive and negative examples were analyzed separately from the participant gender and role gender data.

(verify hypotheses): Guessing (parameter):

positive examples tends to guess by teacher

negative examples is more likely to guess by students

Thank You !