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A Study on Bilingual Semantic Processing: Category Effects and Age Effects

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***Abstract*—**The present study addressed the nature of bilingual semantic processing in Mandarin Chinese and Southern Min and examined category effects and age effects. Nineteen bilingual adults of Mandarin Chinese and Southern Min, nine monolingual seniors of Mandarin Chinese, and ten monolingual seniors of Southern Min in Taiwan individually completed two semantic tasks: Picture naming and category fluency tasks. The instruments for the naming task were sixty black-and-white pictures, including thirty-five object pictures and twenty-five action pictures. The category fluency task also consisted of two semantic categories – objects (or nouns) and actions (or verbs). The reaction time for each picture/question was additionally calculated and analyzed. Oral productions in Mandarin Chinese and in Southern Min were compared and discussed to examine the category effects and age effects. The results of the category fluency task indicated that the content of information of these seniors was comparatively deteriorated, and thus they produced a smaller number of semantic-lexical items. Significant group differences were also found in the reaction time results. Category effects were significant for both adults and seniors in the semantic fluency task. The findings of the present study will help characterize the nature of the bilingual semantic processing of adults and seniors, and contribute to the fields of contrastive and corpus linguistics.

***Keywords*—**Bilingual semantic processing, aging, Mandarin Chinese, Southern Min.

I. Introduction

OVER the past decades, several researchers have examined the issue of aging and its impact on lexical-semantic processing in picture naming, but the results are bifurcated (e.g., [1]-[4]). Most reports have indicated that seniors made more errors in picture naming than young adults, but such differences are not obvious for those younger than seventy (e.g., [5]-[7]). Others argue that the age effect is not significant for seniors who possess a greater amount of vocabulary or who excel in recognizing some unique items in picture naming [4].

Studies on aging and lexical processing have pointed out a number of key factors [8]-[10]. It is commonly found that senior participants are comparatively slower in responding to picture naming and lexical processing than the young participants. Most of these studies examine the features or categories of test pictures in order to elaborate the issue whether the aging brain is more slowly responding to certain types of pictures or items. For example, [6] indicated that the complexity of pictures influences the senior participants' responses to pictures, which is rarely found in the young participants' performance. This finding reveals that age effects and picture effects are influential in the lexical processing. It is, however, generally agreed that lexical or semantic processing in senior and young participants is comparable and worthy of further investigation [6], [11].

According to [7], tip-of-tongue experiences, TOT, is proven to offer convincing empirical evidence to account for why senior participants have greater difficulty in finding words and producing them in an accurate phonetic form. In some cases, young participants might also suffer from TOT, but they try to express the possible semantic information of the word they forget. Their phonetic production might offer some missing information, for example, some syllables or some phonemes [12]-[14]. For senior participants, this word-finding failure is often viewed as problems of aging and cognitive processing, which bothers them the most [15]-[17].

A number of research studies on the age effect on the performance of picture naming have identified several key factors, including category factors and task factors (e.g., [8]-[10]). So far, however, little attention has been directed to the issue of bilingual semantic processing in naming pictures and in vocabulary fluency. This paper aims to elucidate the nature of bilingual semantic processing in Mandarin Chinese and Southern Min. Category effects and age effects are examined in picture naming and category fluency tasks. Data were collected from bilingual adults, monolingual seniors of Mandarin Chinese and monolingual seniors of Southern Min in Taiwan. The study aimed to examine to what extent and in what way healthy bilingual adult speakers of Mandarin Chinese and Southern Min differ semantically from healthy monolingual senior speakers, either of Mandarin Chinese or of Southern Min. The semantic tasks included picture naming, vocabulary fluency. The research questions are listed below:

1. To what extent and in what way do young adult speakers of Mandarin Chinese perform differently from senior speakers of Chinese in picture naming and vocabulary fluency?
2. To what extent and in what way do young adult speakers of Southern Min perform differently from senior speakers of Southern Min in picture naming and vocabulary fluency?

II. Method

In this section, the design of the current research is introduced. A description of the participants, procedures (two semantic tasks: the naming task and category fluency task) and data analysis is explicitly presented.

A. Participants

Thirty-eight persons participated in the study. These participants were further divided into three subgroups: nineteen

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bilingual adults (BA) (ranging from 20 to 30 years old), nine monolingual senior speakers of Mandarin Chinese (MS) (ranging from 60 to 83 years old), and ten monolingual senior speakers of Southern Min (SS) (ranging from 60 to 83 years old). All participants were born in Taiwan.

B. Procedures

Each participant was individually asked to complete two tasks: A naming task and a category fluency task. Oral productions were tape-recorded, and recording was stopped after the participants indicated that they had finished or after 30 seconds of silence. The procedures of implementing these tasks are detailed below.

C. Naming Task

The instruments for the naming task were sixty black-and-white pictures: thirty-five object and twenty-five action pictures, designed by the research group and piloted before the data collection. The object pictures included two sub-types: living objects (i.e., animals, plants, vegetables, fruits) and non-living objects (i.e., vehicles, furniture, and daily commodities). As for the action pictures, they were divided into two sub-types: action verbs (i.e., transitive verbs, intransitive verbs, position verbs, movement verbs) and process verbs [18], [19].

D. Category Fluency Task

The category fluency task consisted of two different semantic categories – objects and actions. The participants were asked to report as many items within a category as possible in one minute. The category of objects was divided into two sub-types: Living objects and non-living objects, while the category of action was inclusive of action verbs and process verbs. Two examples of each sub-category were given to the subjects as references. These examples were not counted in the final scores. Scores of action fluency and of object fluency were a summation of correct responses in these two categories.

E. Data Analysis

The participants' performance data in the two tasks (i.e., Naming Task, Category Fluency Task) were analyzed. Recorded speech samples were transcribed by two students of linguistics and checked by the researcher. All speech transcripts were coded independently by these trained examiners. Any disagreements were discussed and resolved.

III. Results & Discussion

This section offers statistical results and discussion concerning to what extent and in what way healthy bilingual adult speakers of Mandarin Chinese and Southern Min differed semantically from healthy monolingual senior speakers. Either of Mandarin Chinese or of Southern Min. Oral semantic performances of Mandarin Chinese produced by bilingual adults and monolingual seniors are first compared, followed by the results of the semantic production of Southern Min by bilingual adults and monolingual seniors.

A. Bilingual Adults vs. Monolingual Seniors of Mandarin Chinese

The oral performances of the bilingual adults and monolingual seniors of Mandarin Chinese are presented in this subsection. The statistical results of the naming task and the category fluency task are reported below.

B. Picture Naming of Mandarin Chinese

Concerning the results of the accuracy rate in Mandarin Chinese naming, a significant effect of the group factor was first identified in both action naming ($t=2.49$, $p<.05$) and object naming ($t=5.73$, $p<.001$) (Table I). This implies that these groups differed significantly in naming pictures. Secondly, judging from the mean scores, the senior participants scored significantly lower for the action pictures (M=0.52) than the young adult group (M=0.88). Thirdly, the findings for the object naming resemble those for the action naming in two respects. The senior participants (M=0.82) obtained significantly lower scores for the object naming than the young adults (M=0.98).

TABLE I
ACCURACY RATE IN PICTURE NAMING OF MANDARIN CHINESE

	Group	N	Mean	SD	t
Object naming	BA	19	0.98	0.02	2.49*
	MS	9	0.82	0.19	
Action naming	BA	19	0.88	0.04	5.73***
	MS	9	0.52	0.18	

Note: N=number; SD= standard deviation; *$p<.05$; **$p<.01$; ***$p<.001$

TABLE II
REACTION TIME IN PICTURE NAMING OF MANDARIN CHINESE

	Group	N	Mean	SD	t
Object naming	BA	19	0.39	0.25	-2.56*
	MS	9	1.30	1.05	
Action naming	BA	19	0.67	0.29	-2.78*
	MS	9	2.08	1.51	

Note: N=number; SD= standard deviation; *$p<.05$

As for the reaction time in Mandarin Chinese picture naming (Table II), the senior participants responded to the pictures of objects with significantly longer reaction times (M=1.30) than did the young adults (M=0.39) ($t=-2.56$, $p<.05$), manifesting that the senior participants were significantly slower in answering questions than the young adults. A similar pattern was observed in their reaction to the action pictures. Significantly longer reaction times were found for the senior group (M=2.08) than for the young adult group (M=0.67) ($t=-2.78$, $p<.05$). It can be argued that the senior participants, who are becoming slower in their cognitive processing, spent significantly more time processing the questions they were asked and responding to the naming of the pictures.

Within-group differences in the picture naming in Mandarin Chinese were further examined. Regarding the accuracy rate in Mandarin Chinese for naming the pictures, a significant object advantage was identified in both the senior group and the young adult group (Table III). The young adults were significantly more accurate in naming pictures of objects (M=0.98) than of action (M=0.88) ($t=7.84$, $p<.001$). In a similar vein, the senior

participants named the pictures of objects with significantly higher mean scores (M=0.82) than those of action (M=0.52) (t=7.56, p<.001).

TABLE III
ACCURACY RATE IN PICTURE NAMING OF MANDARIN CHINESE

Group	Category	N	Mean	SD	t
BA	Object naming	19	0.98	0.02	7.84***
	Action naming	19	0.88	0.04	
MS	Object naming	9	0.82	0.19	7.56***
	Action naming	9	0.52	0.18	

Note: N=number; SD= standard deviation; ***p< .001

TABLE IV
REACTION TIME IN PICTURE NAMING OF MANDARIN CHINESE

Group	Category	N	Mean	SD	t
BA	Object naming	19	0.39	0.25	-7.05***
	Action naming	19	0.67	0.29	
MS	Object naming	9	1.30	1.05	-2.09
	Action naming	9	2.08	1.51	

Note: N=number; SD= standard deviation; ***p< .001

With respect to the within differences of reaction time, a significant object advantage was observed for the young adult group (Table IV). The young adults responded to the pictures of objects with significantly shorter reaction times (M=0.39) than to the action pictures (M=0.67) (t=-7.05, p<.001). Similarly, the senior participants named the pictures of objects in a faster way (M=1.30) than they did for the action pictures (M=2.08) (t=-2.09, p>.05), although the difference did not reach a significant level.

C. Vocabulary Fluency of Mandarin Chinese

In the category fluency task, the participants were asked to report as many items concerning objects and actions within a category as possible in one minute. The scores of action fluency (also called V-fluency) and of object fluency (also called N-fluency) were a summation of the correct responses in these two categories. Between-group differences (bilingual adults vs. seniors of Mandarin Chinese) and within-group differences (N-fluency vs. V-fluency) are presented and discussed below.

The results of the t-tests of between-group differences in Mandarin Chinese N/V fluency (Table V) show that these two groups differed significantly in reporting as many items within a category as possible in one minute. The results further confirmed that the senior participants were significantly worse at offering responses for the action pictures (M = 4.06) than the young adult group (M = 16.05) (t=7.14, p<.001). Similar patterns were found in the results for object fluency. The senior participants made significantly fewer responses in the object fluency task (M = 8.00) than the young adults (M = 27.32) (t=10.80, p<.001). To sum up, these two groups were significantly differentiated according to their performance in the categorical fluency task.

Table VI reports the within-group differences in N/V fluency of Mandarin Chinese. It was found that N-fluency (M=27.32) significantly outperformed V-fluency (M=16.05) for the young adults (t=10.76, p<.001). A similar pattern occurred in the senior group, in which N-fluency (M=8.00) scored significantly higher than V-fluency (M=4.06) (t=4.92, p<.001).

TABLE V
VOCABULARY FLUENCY OF MANDARIN CHINESE (BA VS. MS)

	Group	N	Mean	SD	t
N-fluency	BA	19	27.32	4.83	10.80***
	MS	9	8.00	3.33	
V-fluency	BA	19	16.05	4.86	7.14***
	MS	9	4.06	1.67	

Note: N=number; SD= standard deviation; ***p< .001

TABLE VI
WITHIN-GROUP VOCABULARY FLUENCY OF MANDARIN CHINESE (N-FLUENCY VS. V-FLUENCY)

	Category	N	Mean	SD	t
BA	N-fluency	19	27.32	4.83	10.76***
	V-fluency	19	16.05	4.86	
MS	N-fluency	9	8.00	3.33	4.92*
	V-fluency	9	4.06	1.67	

Note: N=number; SD= standard deviation; *p< .05; ***p< .001

D. Bilingual Adults vs. Monolingual Seniors of Southern Min

In this subsection, the oral performances of the bilingual adults and monolingual seniors of Southern Min are analyzed and compared. The statistical results of the naming task and the category fluency task are summarized below.

E. Picture Naming of Southern Min

Regarding the results of the accuracy rate of picture naming in Southern Min, several findings could be made on the basis of Table VII. Firstly, a significant effect of the group factor was identified in both action naming and object naming. This demonstrates that these groups overall differed significantly in naming pictures (t=3.63, p<.01). Secondly, judging from the mean scores, the senior participants scored significantly lower for the object pictures (M=0.87) than the young adult group (M=0.97) (t=3.39, p<.01). Thirdly, the findings in the action naming resembled those in the object naming in two respects. As in the object naming, the senior participants (M=0.64) obtained significantly lower scores for the action naming than the young adults (M=0.87) (t=3.53, p<.01).

TABLE VII
ACCURACY RATE IN PICTURE NAMING OF SOUTHERN MIN

	Group	N	Mean	SD	t
Object naming	BA	19	0.97	0.02	3.39**
	SS	10	0.87	0.09	
Action naming	BA	19	0.87	0.08	3.53**
	SS	10	0.64	0.20	

Note: N=number; SD= standard deviation; **p< .01

Concerning the reaction time in picture naming in Southern Min (Table VIII), the senior participants responded to the pictures of objects with significantly longer reaction times (M=0.64) than the young adults (M=0.39) (t=-3.57, p<.01), manifesting that the senior participants were significantly slower in answering questions than the young adults. As for their reaction to the action pictures, longer reaction times were found in the senior group (M=1.33) than in the young adult

group (M=0.61), although the difference did not reach a significant level (t=-2.01, p>.05). It can be argued that the senior participants, becoming slower in their cognitive processing, spent significantly more time processing the questions they were asked and responding to the picture naming.

TABLE VIII
REACTION TIME IN PICTURE NAMING OF SOUTHERN MIN

	Group	N	Mean	SD	t
Object naming	BA	19	0.39	0.25	-3.57**
	SS	10	0.64	0.12	
Action naming	BA	19	0.61	0.48	-2.01
	SS	10	1.33	1.08	

Note: N=number; SD= standard deviation; **p< .01

The within-group differences in picture naming in Southern Min were further examined. Regarding the accuracy rate of the Southern Min picture naming, a significant object advantage was identified in both the senior group and the young adult group (Table IX). The young adults were significantly more accurate in naming pictures of objects (M=0.97) than in naming action pictures (M=0.87) (t=6.25, p<.001). In a similar vein, the senior participants named the pictures of objects with significantly higher mean scores (M=0.87) than the action pictures (M=0.64) (t=5.63, p<.001).

TABLE IX
ACCURACY RATE IN PICTURE NAMING OF SOUTHERN MIN

Group	Category	N	Mean	SD	t
BA	Object naming	19	0.97	0.03	6.25***
	Action naming	19	0.87	0.08	
SS	Object naming	10	0.87	0.09	5.63***
	Action naming	10	0.64	0.20	

Note: N=number; SD= standard deviation; ***p< .001

TABLE X
REACTION TIME IN PICTURE NAMING OF SOUTHERN MIN

Group	Category	N	Mean	SD	t
BA	Object naming	19	0.67	0.49	0.90
	Action naming	19	0.61	0.48	
SS	Object naming	10	0.64	0.12	-2.18
	Action naming	10	1.33	1.08	

Note: N=number; SD= standard deviation

With respect to the within-group differences of reaction time (Table X), an action advantage was observed in the young adult group, but there was an object advantage in the senior group. The young adults responded to the pictures of objects with longer reaction seconds (M=0.67) than to the action pictures (M=0.61) (t=0.90, p>.05). By contrast, the senior participants named the pictures of objects in a faster way (M=0.64) than they did for the action pictures (M=1.33) (t=-2.18, p>.05). These differences did not, however, reach a significant level.

F. Vocabulary Fluency of Southern Min

In the category fluency task, scores of action fluency (also called V-fluency) and of object fluency (also called N-fluency) were a summation of correct responses in these two categories. Between-group differences (bilingual adults vs. seniors of Southern Min) and within group differences (N-fluency vs. V-fluency) are presented and discussed below.

TABLE XI
VOCABULARY FLUENCY OF SOUTHERN MIN (BA VS. SS)

	Group	N	Mean	SD	t
N-fluency	BA	19	19.87	4.14	10.30***
	SS	10	5.15	2.44	
V-fluency	BA	19	13.00	2.84	13.34***
	SS	10	3.10	1.13	

Note: N=number; SD= standard deviation; ***p< .001

TABLE XII
WITHIN-GROUP VOCABULARY FLUENCY OF SOUTHERN MIN (N-FLUENCY VS. V-FLUENCY)

Group	Category	N	Mean	SD	t
BA	N-fluency	19	19.87	4.14	10.19***
	V-fluency	19	13.00	2.84	
SS	N-fluency	10	5.15	2.44	3.43*
	V-fluency	10	3.10	1.13	

Note: N=number; SD= standard deviation; *p< .05; ***p< .001

The results of the t-tests of between-group differences in Southern Min N/V fluency (Table XI) indicated that these two groups differentiated significantly in reporting as many items within a category as possible in one min. The results further confirmed that the senior participants were significantly worse at offering responses to the action pictures (M = 3.10) than the young adult group (M = 13.00) (t=13.34, p<.001). Similar patterns were found in the results of object fluency. The senior participants gave significantly fewer responses in the object fluency task (M = 5.15) than the young adults did (M = 19.87) (t=10.30, p<.001). To sum up, these two groups were significantly differentiated according to their performance in the categorical fluency task.

As for the within-group differences in N/V fluency of Southern Min (Table XII), the young adults obtained significantly higher scores in N-fluency (M=19.87) than V-fluency (M=13.00) (t=10.19, p<.001). Similarly, the senior participants scored significantly higher in N-fluency (M=5.15) than V-fluency (M=3.10) (t=3.43, p<.05).

G. Discussion

The current investigation revealed several asymmetrical dimensions of lexical processing performed by bilingual adults and seniors of Mandarin Chinese and Southern Min. These dimensions include the category effects and the age effects.

Concerning the category effects, significant findings were revealed in terms of accuracy rate, reaction time and N/V fluency. In the picture naming performance of Mandarin Chinese, a significant object advantage in the accuracy rate was identified in both the senior group (MS) and the young adult group (BA). With respect to the reaction time, a significant object advantage was observed for the young adult group (BA), but not for the senior group (MS). Significant within-group differences in N/V fluency of Mandarin Chinese were also identified. It was found that N-fluency significantly outperformed V-fluency for both the young adults (BA) and the seniors (MS).

A similar pattern regarding the category effects occurs in the picture naming performance of Southern Min. Regarding the accuracy rate, a significant object advantage was identified in both the senior group (SS) and the young adult group (BA). As for the reaction time, an action advantage was observed in the young adult group, but there was an object advantage in the senior group. These differences did not, however, reach a significant level. Examining the N/V fluency of Southern Min, both the young adults (BA) and the seniors (SS) obtained significantly higher scores in N-fluency than V-fluency.

Age effects are significant in three aspects, including accuracy rate, reaction time and N/V fluency. In the picture naming performance of Mandarin Chinese, a significant effect of the age factor was identified in the accuracy rate of both action naming and object naming. The senior participants (MS) scored significantly lower for the action and object pictures than the young adult group (BA). As for the reaction time in Mandarin Chinese picture naming, the senior participants (MS) responded to the pictures of objects and actions with significantly longer reaction times than did the young adults (BA), manifesting that the senior participants were significantly slower in answering questions than the young adults. It can be argued that the senior participants, who are becoming slower in their cognitive processing, spent significantly more time processing the questions they were asked and responding to the naming of the pictures. In terms of Mandarin Chinese N/V fluency, the senior participants (MS) were significantly worse at offering responses for the action and object pictures than the young adult group (BA). Similarly, age effects are significant in the picture naming performance of Southern Min. A significant age effect was revealed in the accuracy rate of both action naming and object naming. The senior participants (SS) scored significantly lower for the action and object pictures than the young adult group (BA). Concerning the reaction time in picture naming in Southern Min, the senior participants (SS) responded to the pictures of objects with significantly longer reaction times than the young adults (BA). As for their reaction to the action pictures, longer reaction times were also found in the senior group (SS) than in the young adult group (BA), although the difference did not reach a significant level. Regarding the performance in Southern Min N/V fluency, these two groups differentiated significantly in reporting as many items within a category as possible in one min. The senior participants (SS) were significantly worse at offering responses to the object and action pictures than the young adult group (BA). To sum up, these two groups were significantly differentiated according to their performance in the categorical fluency task.

Findings in the current investigation are in agreement with those in previous studies on aging and lexical processing [8]-[10]. It is commonly found that senior participants are comparatively slower in responding to picture naming and lexical processing than the young participants. The present study further contributes the category effects from the perspectives of accuracy rate, reaction time and N/V fluency, and elaborate the issue whether the aging brain is more slowly responding to certain types of pictures.

IV. Conclusion

This paper aims to investigate the semantic processing of bilingual young adults of Mandarin Chinese and of Southern Min, monolingual seniors of Mandarin Chinese, and monolingual seniors of Southern Min. Two semantic tasks were implemented, including picture naming and vocabulary fluency in two languages (Mandarin Chinese vs. Southern Min). Based on their oral performances and statistical comparison, there are a number of significant findings. The major findings and conclusion are summarized below.

First of all, a significant effect of the age factor was identified in these semantic tasks: picture naming (action vs. object) and vocabulary fluency (N-fluency vs. V-fluency). To illustrate, in Mandarin Chinese, the senior participants scored significantly less in accurately naming pictures than the young adults. A similar pattern was observed in Southern Min. Also, these groups of different ages differentiated significantly in reporting as many items of objects and of actions within a category as possible in one minute, that is, N-fluency and V-fluency. The senior groups, either of Mandarin Chinese or of Southern Min, provided significantly fewer items of objects and of actions than the young adult group.

The second finding concerns the reaction time to each picture. The senior monolingual speakers of Mandarin Chinese responded to both object pictures and action pictures with significantly longer reaction times than did the young adults. Similarly, the senior monolingual speakers of Southern Min responded to pictures of objects significantly more slowly than the young adults, but no significant difference was identified in their responses to pictures of actions. This is one example to illustrate the fact that the age factor is somehow less obvious in certain aspects. Another piece of empirical evidence comes from the within-group differences concerning reaction time in picture naming of Mandarin Chinese. A significant object advantage was observed in the young adult group, but this advantage was not significantly identified in the senior group.

Based on the above major findings, this paper contributes to the following two issues. One is concerned with the extent to which and the way in which young adult speakers of Mandarin Chinese perform differently from senior speakers of Chinese in two semantic tasks. The other issue is related to the extent and the way young adult speakers of Southern Min perform differently from senior speakers of Southern Min in these semantic tasks.

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