Scheduling Mental Processes in a Dual Stroop Task with the Critical Path Method: The Effects of Task Difficulty and Practice

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Introduction

In a series of papers, many researchers (eg., Donders, 1869; Sternberg, 1969; Modor and Phillips, 1970) reported that the methodologies accounting for mental processing have implementation to cognitive task.

Donders (1869) proposed subtraction method assumed that all the processes are in series. Suppose the stages with processing are in the series and executed one by one. The reaction time will be the sum of the effect of different serial processes. The disadvantage of the subtraction method can not be applied to determine the order of the processes in the sequence.

Sternberg 's additive-factor method has more interpretation from Donder's subtraction method. For example: a stimulus is diluted to prolong perceptual process and the number of choice is increased to prolong decision process. Then the increase in reaction time obtained by prolonging two processes is the sum of the reaction time by prolonging two processes individually. When two processes are executed concurrently, the effect of prolonging both of the tasks need not be the sum of the effect prolonging them individually. One point has been touched by Sternberg (1969a) is that the effect of prolonging both of two processes in parallel would be the maximum of the effects of prolonging them individually. Sternberg additive-factor method could not have good explanation to the cases in which the processes in a series interact with each other or the processes are not arranged in sequence.

Critical path analysis (Modor & Phillips, 1970), as a technique, was used to be a tool for scheduling and planning the processes in a network. A critical path for a project is a path through the network such that the activities on this path have zero slack, that is all activities and events having zero slack must lie on a critical path, but no other can. A network is a graphical representation of a project plan, showing the interrelationship of the various activities. In the network, activities are graphically represented by arrows, with descriptions time estimates written along the arrow. There are some rules of network as following description. First, before an activity may begin, all activities preceding it should be completed. Secondly, arrows imply logical precedence only. In CPM, the network plan has been completed and the execution time of each activity has been estimated. The time for completing the activities of task can be predicted when the activities are scheduled. One can infer the network logic and estimate the time of processes completion by obtaining network arrangement.

Schweickert applied the critical-path method of scheduling to analyze reaction times in a dual task. Suppose the mental processes needed by a task are arranged in a network, each process had its execution time. No process can be started until all those preceding processes are finished. One can observe the time from the stimulus is represented and the response is made. In a critical path method, each activity in the task is represented by an arrow, and if activity *x* must be completed before activity *y* can begin, then the arrow representing *x* precedes the arrow representing *y*. Assume the mental processes required by a task are arranged in a network in Figure 1 in which each processes has its duration time and response time is the sum of the durations of processes executed on the longest path. If the duration of one of the processes on the longest path is extended, the response time will be change.

There are two ways in connecting processes, one of them is called sequential, which processes joined by a path are executed in serial order (see Figure 1, process A and C). The other one is called collateral, which processes can be executed at the same time (see Figure 1, process A and B). Processes in parallel are extreme examples of collateral processes. Parallel processes should have the same starting point and the terminating point. An special case between sequential and collateral is Wheatstone bridge, in which the network, a hybrid of the two typical patterns, has two processes execution with overlapped duration.

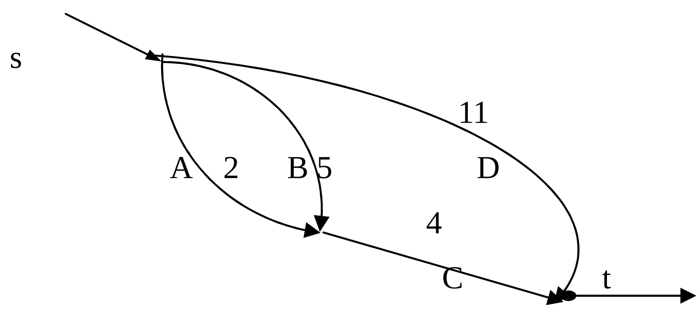


Fig. 1. A task network. (Each arrow has a number giving the duration of the process. No process may begin until all those preceding it should complete.)

In briefly, five equations are provided regarding the application of CPM.
Assuming processes X and Y are on a path.

1. For sequential processes, if x precedes y on a path and if Δx and Δy are not too small,

$$\Delta RT(\Delta X, \Delta Y) = \Delta RT(\Delta X, 0) + RT(0, \Delta Y) + K(XY) \qquad K(XY) \geq 0 \qquad (1)$$

2. For collateral processes,

$$\Delta RT(\Delta X, \Delta Y) = MAX[\Delta RT(\Delta X, 0), \Delta RT(0, \Delta Y)] \qquad (2)$$

3. For two processes with Wheatstone bridge network,

$$RT(X, Y) = RT(X, 0) + RT(0, Y) + K(XY) \qquad K(XY) < 0 \qquad (3)$$

4. If process X precedes process Y which precedes point *v* and *m*

$$\Delta RT_v(\Delta X, \Delta Y) - \Delta RT_v(\Delta X, 0) = \Delta RT_m(\Delta X, \Delta Y) - \Delta RT_m(\Delta X, 0) \qquad (4)$$

5. Three processes are on a path, assume that x precedes y; which precedes z.

$$\Delta RT(\Delta X, \Delta Y, \Delta Z) = \Delta RT(\Delta X, 0, 0) + \Delta RT(0, \Delta Y, 0) + \Delta RT(0, 0, \Delta Z) + K(XY) + K(YZ) \qquad (5)$$

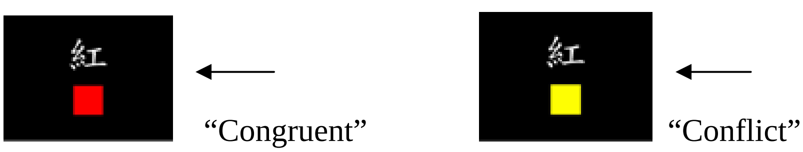
We conducted three dual-task experiments to examine the effects of task difficulty on the scheduling of mental processes, using the method. The ultimate purpose of this study is to provide more experimental evidence how the schedule network of subject's mental process be effected by task difficulty.

Experiment 1A- Word naming task

Schweickert's word naming dual-task (1983) was replicated in this experiment. Subject in this experiment was required to make two responses, which were manual to color and vocal to word on each trial. Subject was demanded to do manual response before vocal one. In this experiment, subject was requested to response by her preferred order.

Stimulus: Word 紅 綠 藍 黃

Colored suare



Results

Those means, along with the overall means across trial blocks, are shown in the Table 1. Table 2 gives the relative information for Experiment 1A.

When the number of colors was increased from one to two, 80=68+21+K(H_1W), K(H_1W) was not significantly different from zero, $F(1, 464)=0.756$, MSe=1454.99, $p<0.385$, as mentioned above equation (1), the processes of W and H may be serial. The rule hold in the case the number of colors was increased from one to four, K(H_2W) did not significantly differ from zero, 103=95+21+K(H_2W), $F(1, 464)=2.57$, MSe=1454.99, $p<0.11$. It is concluded that W and H may be serial.

Equation (1) may be applied to the case, when the number of color is increased from one to two, 231=29+68+K(H_1C), K(H_1C) was significantly greater than zero, F(1, 464)=172.08, MSe=1454.99, $p<0.0001$, H and C may be serial processes.

When the number of colors was increased from one to four, 235=29+95+ $K(H_2C)$, $K(H_2C)$ differed from zero significantly, $F(1, 464)=101.62$, MSe=1454.99, $p<0.00001$, H and C may be serial processes too.

We find that equation (1) and (3) hold for 47=21+29+K(WC), K(WC) was not different from zero precisely, $F(1, 464)=0.023$, MSe=1454.99, $p<0.879$, we may conclude that W and C may be serial.

The locus of W, H and C could be investigated by equation (5) as following.

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

$K(H_1W)=-9$, $K(H_2W)=-13$, $K(H_1C)=134$, $K(H_2C)=107$, $K(WC)=-3$;

$\Delta RT(\Delta H_1, 0, 0)=68$, $\Delta RT(\Delta H_2, 0, 0)=95$, $\Delta RT(0, \Delta W, 0)=21$, $\Delta RT(0, 0, \Delta C)=29$

222=21+68+29+(-9)+(-3). 222=106. error term is 116.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

261=21+95+29+(-13)+(-3). 261=129. error term is 132.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

222=21+68+29+(-9)+134. 222=243. error term is 21.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

261=21+95+29+(-13)+107. 261=239. error term is 22.

Judging from the above, the processes of W, H and C should be serial and the order among these may be $W \rightarrow H \rightarrow C$. Figure 4 shows the network path of W, H and C.

Table 1 Mean RT and STD in Exp. 1A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
2			Vocal			
M	496	561	585	523	701	705
SD	63	82	85	77	108	111
4						
M	515	574	596	540	694	724
SD	78	74	80	82	100	101
	Color					
	Congruent			Conflict		
字	1	2	4	1	2	4
2			Manual			
M	500	570	600	530	757	761
SD	61	84	103	78	152	151
4						
M	522	582	606	550	746	793
SD	72	81	90	81	139	150

Table 2
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 1A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	65	89	27	205	209
4	19	78	100	44	198	228
			Manual			
2	0	70	100	30	257	261
4	22	82	106	50	246	293
			Average			
2	0	68	95	29	231	235
4	21	80	103	47	222	261

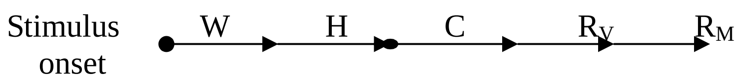


Fig. 2. The scheduling network of word naming in Exp. 1A.

Experiment 1B- Color naming task

Subject in this experiment was required to make two responses in which were manual to word and vocal to color on each trial. The subject was requested to response by her preferred order.

Stimuli: The stimuli were the same as in Experiment 1A.

Results

Those means, along with the overall means across trial blocks, are shown in the Table 3. Table 8 gives the relative information for Experiment 1B.

When the number of colors was increased from one to two, $140=69+64+K(H_1W)$, $K(H_1W)$ was not significantly different from zero, $F(1, 464)=0.3398$, $MSe=2625.05$, $p<0.56$, as mentioned above equation (1), the processes of W and H may be serial. Equation (3) hold in the case the number of colors was increased from one to four, $K(H_2W)$ was significantly less than zero, $148=123+64+K(H_2W)$, $F(1, 464)=6.304$, $MSe=2625.05$, $p<0.012$. It is concluded that W and H may be Wheatstone bridge.

Equation (1) may be implemented to the case, when the number of color is increased from one to two, $324=69+27+K(H_1C)$, $K(H_1C)$ was significantly greater than zero, $F(1, 464)=239.4$, $MSe=2625.05$, $p<0.00001$, H and C may be serial processes.

When the number of colors was increased from one to four, $387=123+27+ K(H_2C)$,

$K(H_2C)$ differed from zero significantly, $F(1, 464)=254.48$, $MSe=2625.05$, $p<0.00001$, H and C may be serial processes too.

We find that equation (1) and (3) hold for $80=64+27+K(WC)$, $K(WC)$ was not different from zero precisely, $F(1, 464)=0.2807$, $MSe=2625.05$, $p<0.5965$, we may conclude that W and C may be serial.

The location of W, H and C could be investigated. Equation (5) hold the order of these three.

$K(H_1W)=7$, $K(H_2W)=-39$, $K(H_1C)=228$, $K(H_2C)=237$, $K(WC)=-11$;

$\Delta RT(\Delta H_1, 0, 0)=69$, $\Delta RT(\Delta H_2, 0, 0)=123$, $\Delta RT(0, \Delta W, 0)=64$, $\Delta RT(0, 0, \Delta C)=27$

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

$357=64+69+27+7+(-11)$. $357=156$. error term is 201.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

$412=64+123+27+(-39)+(-11)$. $412=164$. error term is 248.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

$357=64+69+27+7+228$. $357=395$. error term is 38.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

$412=64+123+27+(-39)+237$. $412=412$. error term is 0.

Judging from the analysis mentioned above, the number of colors was increased one to two, the processes of W, H and C should be serial and the order of these three may be $W \rightarrow H \rightarrow C$. Figure 3 shows the network path of W, H and C; whereas the number of colors was increased one to four, the processes of W, H and C should be Wheatstone bridge and the order was $W \rightarrow H \rightarrow C$. The figure was shown in Figure 4.

Table 7 Mean RT and STD in Exp. 2B

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2						
M	515	582	637	542	811	868
SD	97	118	130	94	167	156
4						
M	576	648	660	594	837	881
SD	95	133	109	110	166	151

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Manual			
2						
M	526	597	650	553	878	946
SD	91	107	138	92	219	213
4						
M	592	673	677	607	917	984
SD	144	152	140	111	235	220

Table 4
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 1B

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	67	122	27	296	353
4	61	133	145	79	322	366
			Manual			
2	0	71	124	27	352	420
4	66	147	151	81	391	458
			Average			
2	0	69	123	27	324	387
4	64	140	148	80	357	412

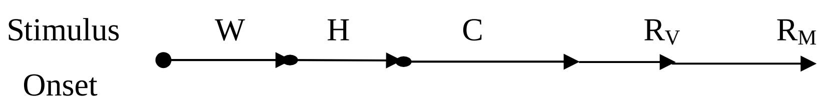


Fig. 3. The scheduling network of color naming in Exp. 1B. (The number color is increased from one to two.)

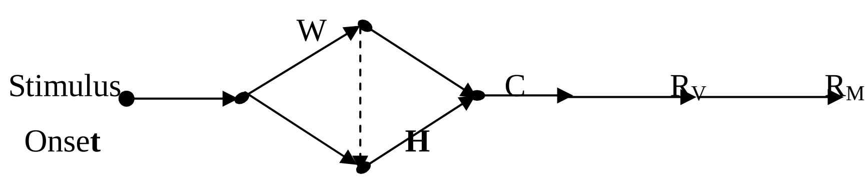
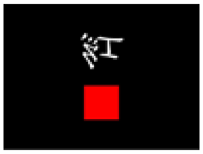


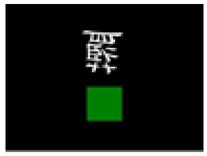
Fig. 4. The scheduling network of color naming in Exp. 1B. (The number color is increased from one to four.)

Experiment 2A- Word naming task

Subject in this experiment was required to make two responses in which were manual to word and vocal to color on each trial. The subject was requested to response by her preferred order.

Stimuli: The stimuli were similar with those in Experiment 1A except what the word was presented. The colored-word was showed as a mirror-reverse image.





Results

Those means, along with the overall means across trial blocks, are shown in the Table 5. Table 6 gives the relative information for Experiment 2A.

When the number of colors was increased from one to two, $71=54+9+K(H_1W)$, $K(H_1W)$ was not significantly different from zero, $F(1, 464)=0.377$, $MSe=2232.03$, $p<0.54$, as mentioned above equation (1), the processes of W and H may be serial. Equation (3) hold in the case the number of colors was increased from one to four, $K(H_2W)$ was significantly less than zero, $92=104+9+K(H_2W)$, $F(1, 464)=2.7$, $MSe=2232.03$, $p<0.1$. It is concluded that W and H may be Wheatstone bridge.

Equation (1) may be implemented to the case, when the number of color is increased from one to two, $65=4+54+K(H_1C)$, $K(H_1C)$ was not significantly different from zero, $F(1, 464)=0.379$, $MSe=2232.03$, $p<0.538$, H and C may be serial processes.

When the number of colors was increased from one to four, $114=104+4+K(H_2C)$, $K(H_2C)$ did not differ from zero significantly, $F(1, 464)=0.268$, $MSe=2232.03$, $p<0.601$, H and C may be serial processes too.

We find that equation (1) and (3) hold for $25=4+9+K(WC)$, $K(WC)$ was not different from zero precisely, $F(1, 464)=0.938$, $MSe=2232.03$, $p<0.333$, we may conclude that W and C may be serial.

The location of W, H and C could be investigated. Equation (5) hold the order of these three.

$K(H_1W)=8$, $K(H_2W)=-21$, $K(H_1C)=8$, $K(H_2C)=7$, $K(WC)=-13$;

$\Delta RT(\Delta H_1, 0, 0)=54$, $\Delta RT(\Delta H_2, 0, 0)=104$, $\Delta RT(0, \Delta W, 0)=9$, $\Delta RT(0, 0, \Delta C)=4$

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

$88=9+54+4+8+13$. error term is 1.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

$117=9+104+4+(-21)+13$. error term is 8.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

$88=9+54+4+8+8$. error term is 5.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

$117=9+104+4+(-21)+6$. error term is 15.

Judging from the analysis mentioned above, the number of colors was increased one to two, the processes of W, H and C should be serial and the order of these three may be $W \rightarrow H \rightarrow C$. Figure 5 shows the network path of W, H and C; whereas the number of colors was increased one to four, the processes of W, H and C should be Wheatstone bridge and the order was $W \rightarrow H \rightarrow C$. The figure was shown in Figure 6.

Table 5 Mean RT and STD in Exp. 2A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2						
M	626	655	689	631	654	704
SD	82	90	80	75	69	68
4						
M	629	671	686	645	677	708
SD	78	82	73	68	68	93

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Manual			
2						
M	493	572	638	495	595	643
SD	87	66	59	78	59	55
4						
M	507	589	617	524	617	644
SD	73	71	44	92	83	58

Table 4
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 2A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	79	145	2	102	150
4	14	96	124	31	124	151
			Manual			
2	0	29	69	5	28	78
4	3	45	60	19	51	82
			Average			
2	0	54	104	4	65	114
4	9	71	92	25	88	117

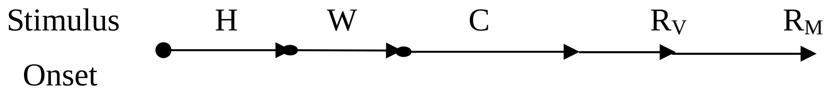


Fig. 5. The scheduling network of word naming in Exp. 2A. (The number color is increased from one to two.)

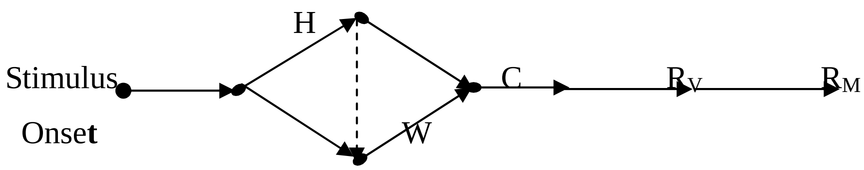


Fig. 6. The scheduling network of word naming in Exp. 2A. (The number color is increased from one to four.)

Experiment 2B- Color naming task

Subject in this experiment was required to make two responses in which were manual to word and vocal to color on each trial. The subject was requested to response by her preferred order.

Stimuli: The stimuli were similar with those in Experiment 1A except what the word was presented. The colored-word was showed as a mirror-reverse image.

Results

Those means, along with the overall means across trial blocks, are shown in the Table7. Table 8 gives the relative information for Experiment 2B.

When the number of colors was increased from one to two, 231=60+177+K(H_1W), K(H_1W) was not significantly different from zero, $F(1, 464)=0.177$, $MSe=5416.3$, $p<0.674$, as mentioned above equation (1), the processes of W and H may be serial. Equation (3) hold in the case the number of colors was increased from one to four, K(H_2W) was slightly less than zero, 223=60+186+K(H_2W), $F(1, 464)=2.54$, $MSe=5416.3$, $p<0.11$. It is concluded that W and H may be Wheatstone bridge.

Equation (1) may be implemented to the case, when the number of color is increased from one to two, 171=177+2+K(H_1C), K(H_1C) was not significantly different from zero, $F(1, 464)=0.04$, $MSe=5416.3$, $p<0.884$, H and C may be serial processes.

When the number of colors was increased from one to four, 218=186+2+ K(H_2C), K(H_2C) did not differ from zero significantly, $F(1, 464)=3.5$, $MSe=5416.3$, $p<0.062$, H and C may be serial processes too.

We find that equation (1) and (3) hold for 68=2+60+K(WC), K(WC) was not different from zero precisely, $F(1, 464)=0.668$, MSe=5416.3, $p<0.414$, we may conclude that W and C may be serial.

The location of W, H and C could be investigated. Equation (5) hold the order of these three.

$K(H_1W)=-6$, $K(H_2W)=-22$, $K(H_1C)= -8$, $K(H_2C)=31$, $K(WC)=7$;

$\Delta RT(\Delta H_1, 0, 0)=177$, $\Delta RT(\Delta H_2, 0, 0)=186$, $\Delta RT(0, \Delta W, 0)=60$, $\Delta RT(0, 0, \Delta C)=2$

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

265=60+177+2+(-6)+7. error term is 26.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

241=60+186+2+(-22)+7 . error term is 7.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

265=60+177+2+(-6)+(-8). error term is 41.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

241=60+186+2+(-22)+31. error term is 15.

Judging from the analysis mentioned above, the number of colors was increased one to two, the processes of W, H and C should be serial and the order of these three may be W→H→C. Figure 7 shows the network path of W, H and C; whereas the number of colors was increased one to four, the processes of W, H and C should be Wheatstone bridge and the order was W→H→C. The figure was shown in Figure 8.

Table 7 Mean RT and STD in Exp. 2A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
2	Vocal					
M	710	870	892	712	875	915
SD	63	80	86	65	81	67
4						
M	760	908	917	772	956	936
SD	104	112	89	96	98	83

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
2	Manual					
M	818	1012	1007	820	995	1049
SD	119	101	96	116	110	96
4						
M	887	1081	1057	892	1102	1075
SD	141	123	129	103	144	93

Table 8
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 2A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	160	182	2	165	205
4	50	198	207	62	246	226
			Manual			
2	0	194	189	2	177	231
4	69	263	239	74	284	255
			Average			
2	0	177	186	2	171	218
4	60	231	223	68	265	241

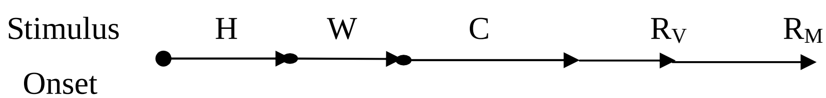


Fig. 7. The scheduling network of color naming in Exp. 2B.(The number color is increased from one to two.)

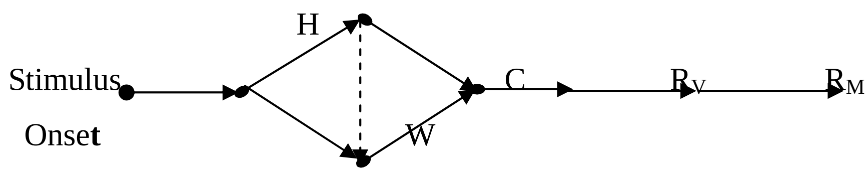
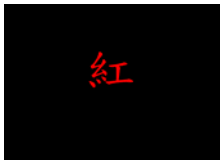


Fig. 8. The scheduling network of color naming in Exp. 2B.(The number color is increased from one to four.)

Experiment 3A- Word naming task

Subject in this experiment was required to make two responses in which were manual to word and vocal to color on each trial. The subject was requested to response by her preferred order.

Stimuli: The two stimuli including word and colored rectangle merged into one stimulus.



Results

Those means, along with the overall means across trial blocks, are shown in the Table 9. Table 10 gives the relative information for Experiment 3A.

When the number of colors was increased from one to two, $59=4+47+K(H_1W)$, $K(H_1W)$ was not significantly different from zero, $F(1, 464)=0.26$, $MSe=3599.44$, $p<0.61$, as mentioned above equation (1), the processes of W and H may be serial. Equation (3) hold in the case the number of colors was increased from one to four, $K(H_2W)$ was not significantly different from zero, $93=4+81+K(H_2W)$, $F(1, 464)=0.3$, $MSe=3599.44$, $p<0.584$. It is concluded that W and H may be serial.

Equation (1) may be implemented to the case, when the number of color is increased from one to two, $81=7+47+K(H_1C)$, $K(H_1C)$ was not significantly different from zero, $F(1, 464)=2.57$, $MSe=3599.44$, $p<0.109$, H and C may be serial processes.

When the number of colors was increased from one to four, $123=7+81+ K(H_2C)$, $K(H_2C)$ differ from zero significantly, $F(1, 464)=4.26$, $MSe=3599.44$, $p<0.039$, H and C may be serial processes too.

We find that equation (1) and (3) hold for $15=4+7+K(WC)$, $K(WC)$ was not different from zero precisely, $F(1, 464)=0.11$, $MSe=3599.44$, $p<0.74$, we may conclude that W and C may be serial.

The location of W, H and C could be investigated. Equation (5) hold the order of these three.

$K(H_1W)=8$, $K(H_2W)=8$, $K(H_1C)= 27$, $K(H_2C)=35$, $K(WC)=4$;

$\Delta RT(\Delta H_1, 0, 0)=47$, $\Delta RT(\Delta H_2, 0, 0)=81$, $\Delta RT(0, \Delta W, 0)=4$, $\Delta RT(0, 0, \Delta C)=7$

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

$92=4+47+7+8+4$. error term is 22.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

$139=4+81+7+8+4$. error term is 35.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

$92=4+47+7+8+27$. error term is 1.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

$139=4+81+7+8+35$. error term is 4.

Judging from the analysis mentioned above, the number of colors was increased one to two, the processes of W, H and C should be serial and the order of these three may be $W \rightarrow H \rightarrow C$. Figure 9 shows the network path of W, H and C.

Table 9 Mean RT and STD in Exp. 3A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2						
M	579	580	586	581	599	625
SD	23	33	54	32	56	44
4						
M	581	589	600	589	608	627
SD	46	60	61	32	52	80
	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Manual			
2						
M	503	595	658	515	645	703
SD	56	63	75	63	56	76
4						
M	509	610	668	523	658	733
SD	54	66	76	50	86	82

Table 10
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 3A

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	1	7	2	20	46
4	2	10	21	10	29	48
			Manual			
2	0	92	155	12	142	200
4	6	107	165	20	155	230
			Average			
2	0	47	81	7	81	123
4	4	59	93	15	92	139

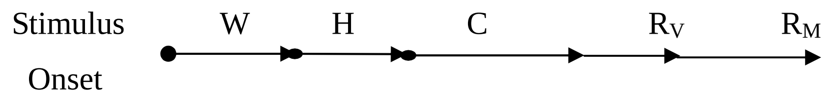


Fig. 9. The scheduling network of word naming in Exp. 3A.

Experiment 3B- Word naming task

Subject in this experiment was required to make two responses in which were manual to word and vocal to color on each trial. The subject was requested to response by her preferred order.

Stimuli: The stimuli were the same as the Exp. 3A

Results

Those means, along with the overall means across trial blocks, are shown in the Table 11. Table 12 gives the relative information for Experiment 3B.

When the number of colors was increased from one to two, 226=77+151+K(H_1W), K(H_1W) was not significantly different from zero, F(1, 464)=0.177, MSe=3977.67, p<0.959, as mentioned above equation (1), the processes of W and H may be serial. Equation (3) hold in the case the number of colors was increased from one to four, K(H_2W) was not significantly different from zero, 288=77+233+K(H_2W), F(1, 464)=1.376, MSe=3977.67, p<0.241. It is concluded that W and H may be serial.

Equation (1) may be implemented to the case, when the number of color is increased from one to two, 247=15+151+K(H_1C), K(H_1C) was not significantly different from zero, F(1, 464)=20.07, MSe=3977.67, p<0.241, H and C may be serial processes.

When the number of colors was increased from one to four, 327=15+233+ K(H_2C), K(H_2C) differ from zero significantly, F(1, 464)=18.54, MSe=3977.67, p<0.0001, H and C may be serial processes too.

We find that equation (1) and (3) hold for 99=15+77+K(WC), K(WC) was not different from zero precisely, F(1, 464)=0.217, MSe=3977.67, p<0.641, we may conclude that W and C may be serial.

The location of W, H and C could be investigated. Equation (5) hold the order of these three.

K(H_1W)=-1, K(H_2W)=-22, K(H_1C)= 82, K(H_2C)=79, K(WC)=8;

ΔRT(ΔH_1, 0, 0)=151, ΔRT(ΔH_2, 0, 0)=233, ΔRT(0, ΔW, 0)=77, ΔRT(0, 0, ΔC)=15

If the order of W, H_1 and C is $H_1 \rightarrow W \rightarrow C$,

342=77+151+15+(-1)+8. error term is 92.

If the order of W, H_2 and C is $H_2 \rightarrow W \rightarrow C$,

414=77+233+15+(-22)+8. error term is 103.

On the other hand, if the order of W, H_1 and C is $W \rightarrow H_1 \rightarrow C$,

342=77+151+15+(-1)+82. error term is 18.

If the order of W, H_2 and C is $W \rightarrow H_2 \rightarrow C$,

414=77+233+15+(-22)+79 . error term is 32.

Judging from the analysis mentioned above, the number of colors was increased one to two, the processes of W, H and C should be serial and the order of these three may be

W→H→C. Figure 10 shows the network path of W, H and C.

Table 11 Mean RT and STD in Exp. 3B

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2						
M	575	744	838	603	863	984
SD	58	67	62	63	88	64
4						
M	621	796	863	645	933	1033
SD	67	80	90	69	94	77

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Manual			
2						
M	464	596	667	465	670	708
SD	64	56	79	59	87	72
4						
M	571	695	752	592	790	834
SD	73	86	77	60	105	91

Table 12
Changes in RT with Respect to One-Word, Two-Color, No-Conflict Conditions in Exp. 3B

	Color					
	Congruent			Conflict		
Word	1	2	4	1	2	4
			Vocal			
2	0	169	263	28	288	409
4	46	221	288	70	358	458
			Manual			
2	0	132	203	1	206	244
4	107	231	288	128	326	370
			Average			
2	0	151	233	15	247	327
4	77	226	288	99	342	414

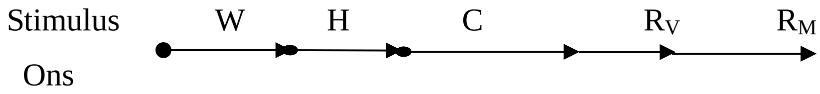


Fig. 10. The scheduling network of color naming in Exp. 3B.

Discussion

The results of these experiments show that the scheduling networks of subject's mental process are influenced by three main causes. This finding is consistent with Meyer and Kieras's AEC models which provide reasonable explanation.

1. The subjects of the three dual-task experiments were requested to do response by their own preferred order. The results from Exp. 1 showed that the stimulus 'word' was always processed before 'color' regardless of the task. The phenomena of preference in words resulted from automaticity because of practice. It is usually found that the word-naming task does have speed of processing compared with color-naming (LaBerge, Samuel, 1974; Morton, 1969; Posner, Snyder, 1975; Logan, 1980).
2. Set size of stimulus might affect subject's scheduling network, as indicated from the results of Exp. 2A. When the set size is increased, the scheduling network of subject's mental process changes from serial process to Wheatstone bridge process.
3. Exp. 2 and Exp. 3 varied task difficulty by manipulating the type of stimuli. The results showed that when the task difficulty increased, the scheduling network of the subject's mental processes shifted from one containing a Wheatstone bridge to one of serial process. The results also showed that the task of dual-task with higher S-R compatibility might be processed before the one with lower S-R compatibility. It seems that the subjects may use different task-scheduling strategies under various task difficulty. A cautious strategy without overlap in processing for two tasks is characterized by serial scheduling network Subject's mental schedule should be arranged in the way of one by one if the two tasks are difficult. On the other hand, a daring strategy with a great deal of processing overlap is represented in Wheatstone bridge. That is, subject's mental schedule might be arranged in a concurrent way if the two tasks are easy.

The present three experiments offer some information about what factors contribute to the task scheduling. Dual-task performance is mediated by central system (AEC) that uses flexible strategies of task scheduling in order to have optimal arrangement. Although the information obtained, much remains to be discovered about how the task difficulty is measured and what factors except task difficulty govern the scheduling strategy. Does task priority influence the choice of scheduling strategy. Would practice enable the subject to change task scheduling? Yet more research issues will be developed and definitive answers will be obtained.

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