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# Task Switching between Face Categorizations: an Advance Preparation Effect

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*Abstract-* This study examined how advance preparation modulates our ability to switch between face categorizations. The study included three switching experiments with different pairs of facial categorization tasks. In experiment 1, subjects switched between gender and occupation categorizations. Results showed a larger switch cost for the occupation task. In experiment 2, participants categorized emotion and gender categorizations. Results yielded a larger switch cost for the gender task. In experiment 3, subjects performed emotion and occupation categorization task. There was a larger switch cost for the occupation task. The overall results of experiments indicated that harder task yielded a larger switch cost than the easier task. Moreover, these switch costs can be reduced with sufficient preparation time. This study is the first investigation into advance preparation effect during switching between tasks of social significance. We discuss why asymmetries reduce with an advance preparation during face categorization tasks.

*Keywords:* *task switching; emotion; advance preparation; face categorization.*

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# Task Switching between Face Categorizations: an Advance Preparation Effect

Amara Gul [α] & Glyn W. Humphreys [σ]

*Abstract-* This study examined how advance preparation modulates our ability to switch between face categorizations. The study included three switching experiments with different pairs of facial categorization tasks. In experiment 1, subjects switched between gender and occupation categorizations. Results showed a larger switch cost for the occupation task. In experiment 2, participants categorized emotion and gender categorizations. Results yielded a larger switch cost for the gender task. In experiment 3, subjects performed emotion and occupation categorization task. There was a larger switch cost for the occupation task. The overall results of experiments indicated that harder task yielded a larger switch cost than the easier task. Moreover, these switch costs can be reduced with sufficient preparation time. This study is the first investigation into advance preparation effect during switching between tasks of social significance. We discuss why asymmetries reduce with an advance preparation during face categorization tasks.

*Keywords: task switching; emotion; advance preparation; face categorization.*

## I. Introduction

### a) Face Categorization

An observer perceives several attributes while looking at a face such as expressions of emotion, gender, identity. Classic model of face processing by Bruce and Young (1986) suggests that face processing involves several functionally independent processing modules. The model assumes that identification of a familiar face involves the formation of a view independent structural description, which could be compared with all known faces stored in Face Recognition Units, followed by the identification of particular person and retrieval of semantic information, after which there is activation of the phonological codes. These codes underlie the name-related information of the person. Bruce and Young suggest that the recognition of facial emotion and identity are operated through distinct processes. Neuropsychological studies argue that emotion processing is automatic (Vuilleumier et al., 2001, 2002) whereas non -emotion features are not automatically categorized (Quinn, Mason, & Macrae, 2009). Facial emotion can be processed independent of face identity (Humphreys, Donnelly, & Riddoch, 1993). Emotion is processed by specialized sub-cortical routes to amygdala which by pass cortical processes involved in the identity coding (Haxby, Hoffman, & Gobbinni, 2000). Patients with prosopagnosia and anomic aphasia successfully categorize gender, indicating that these processes rely on different mechanisms which are required for face recognition (Clarke et al., 1997; Flude, Ellis, & Kay, 1989). In addition, face identification and emotion discrimination can also dissociate (Parry, Young, Saul, & Moss, 1991). Given the differing patterns of dissociation, we hypothesized that substantial effects of task switching may occur, when participants shift from one face classification task to another.

### b) Task Switching

Task switching is an experimental paradigm to examine cognitive control. Our daily routine requires the processing of several tasks. In order to perform speeded switching, the cognitive control is required. In task switching experiments, generally two tasks are presented. The trials where the task is switched called as switch trials, whereas the trials where the task remains the same as on the previous trial are known as repeat trials. The switch cost was measured as the difference in reaction times on switch and repeat trials. Jersild (1927) presented the first task switching experiment with two conditions. The experimental condition involved switching between two tasks while the control condition had a single task. Switch cost was measured as difference of performance between these two conditions. In order to avoid such a confound Rogers and Monsell (1995) presented two tasks in an alternating-run, for example a letter (L) and digit (D) categorization (LDLDLDLD…). This method allowed computation of switch cost as a differential performance between switch and repeat trials. Each task yields a specific rule. Switching requires an activation of the relevant task-rule and inhibition of the task-rule which is no more relevant on the current trial (Mayr & Keele, 2000; Meiran, 1996). Cortical network of frontal and parietal areas are strongly activated during task switching, thus advance preparation benefits are rather prominent on switch trials (Ruge et al., 2005). By varying the interval between cue and stimulus, one can measure the time utilized by cognitive system for an active preparation of the upcoming task. Switch cost is decreased with long cue-stimulus intervals (CSI), for

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example when switching between a digit and a letter task, reaction times (RTs) on switch and repeat trials speeded up from short (150 ms) to long (600 ms) CSI (Rogers & Monsell, 1995; Nicholson et al., 2005). To date, it is unclear whether advance preparation can modulate switching ability between different pairs of face categorization tasks. Therefore, we selected faces as experimental stimuli. We manipulated CSI (Experiments 1-3) to dissociate the time taken to prepare for the upcoming task from the switch costs. The cue preceded the stimulus at various time intervals to examine the advance preparation effects. We hypothesized that a reduction in switch cost would arise with long CSI.

## II. Experiment 1: Gender-Occupation Task Switching

### a) Method

#### i. Participants

24 postgraduate students (8 female and 16 male, ages 21-25 years, mean 23.37 years) took part exclusively in experiment 1.

#### ii. Materials and displays

The stimuli were 16 faces in color bitmap images (standardized to 300 × 300 pixels & matched subjectively for luminance and contrast) of 8 famous singers and actors which depicted happy and neutral facial emotional expression. Half of the images were of women. The 8 photos of singers comprised Robbie Williams, Paul McCartney, Britney Spears, Madonna, while 8 photos of actors included Daniel Radcliffe, Rowan Atkinson, Kate Winslet, and Elizabeth Taylor. The tasks included gender (G) and occupation (O) categorization. These stimuli were embedded in Rogers and Monsell's (1995) alternating-run task switching paradigm (GOGOGOGO…). The experiment was designed in E-prime software (Schneider, Eschman, & Zuccolotto, 2002, version 1.2). The CSI was set to 150, 700, 1000 ms presented randomly throughout the experiment. The order of the CSI and tasks were completely counterbalanced across participants. Each trial consisted of a fixation (+) displayed for 1000 ms, followed by the colored screen (black screen as a cue to gender and blue screen as a cue to occupation categorization), then the face appeared in center of the screen. A manual response was made to the face by pressing keys on the key board: 1=male, 2=female, 3=actor, 4=singer. The stimuli were presented on a 14 inch laptop and remained on the screen until the response was made. Participants were presented with 241 trials experimental trials.

#### iii. Procedure

Upon arrival in the experimental room, participants were given an informed consent form to review and sign. Upon consent, they were given a description of the procedure. Next, s/he was seated before the laptop at a comfortable viewing distance. Participants were told that this was a reaction time experiment and they must engage actively in preparation for the upcoming task as signaled by the colored screen. They were instructed to respond to the faces by pressing the fixed keys on keyboard as quickly as possible without sacrificing accuracy. On each trial, participants were presented with a face and they were required to judge gender or occupation of the face in 241 experimental trials of the gender and occupation task. Following the experiment, the results were saved and participants were debriefed and thanked for their participation.

### b) Results

Response times (RTs) for the first trial were discarded because no task switch took place, then outliers were removed and RTs were excluded above 2.5 standard deviations from each participants' mean. Mean RTs were submitted to a repeated measures analysis of variance (ANOVA) with trial (switch vs. repeat) x task (gender vs. occupation) x CSI (150 vs. 700 vs. 1000 ms) as within subject factors. The main effect of trial was significant $F(1, 23) = 148.12$, $p < 0.001$, $MSE = 163641.73$, $\eta p2 = .86$. RTs were slower on switch than on repeat trials ($M = 1436$ vs. 856 ms). There was a reliable main effect of the task $F(1, 23) = 101.00$, $p < 0.001$, $MSE = 16480.47$, $\eta p2 = .81$. RTs were faster on gender than the occupation task ($M = 1070$ vs. 1222 ms). Main effect of CSI was significant $F(2, 23) = 36.00$, $p < 0.001$, $MSE = 260309.46$, $\eta p2 = .60$, CSI 150 ms $M = 1396$ ms, CSI 700 ms $M = 1061$ ms, CSI 1000 ms $M = 981$ ms. There was a significant interaction between Trial x CSI $F(2, 23) = 9.20$, $p < 0.001$, $MSE = 68031.51$, $\eta p2 = .28$. Switch cost decreased with larger CSI (CSI 150 ms $M = 707$ ms, CSI 700 ms $M = 548$ ms, CSI 1000 ms $M = 485$ ms).There was a significant interaction between Trial x Task $F(1, 23) = 23.00$, $p < 0.001$, $MSE = 5251.37$, $\eta p2 = .49$. The switch cost for occupation was larger than the gender task $t(23) = 4.79$, $p < 0.001$, $M = 621$ vs. 539 ms. The interactions between Task x CSI [$F(2, 23) = .85$, $p = .43$, $MSE = 6380.20$, $\eta p2 = .03$] and Task x CSI x Trial [$F(2, 23) = 1.13$, $p = .33$, $MSE = 8591.84$, $\eta p2 = .04$, Fig.1] were not reliable.

### c) Errors

Errors for the first trial were discarded because no task switch took place, then mean errors were submitted to a repeated measures analysis of variance (ANOVA) with trial (switch vs. repeat) x task (gender vs. occupation) x CSI (150 vs. 700 vs. 1000 ms) as within subject factors. The main effect of trial was significant $F(1, 23) = 25.48$, $p < 0.001$, $MSE = .03$, $\eta p2 = .52$. Errors were higher on repeat than on switch trials ($M = .07$ vs. 06). There was a reliable main effect of the task $F(1, 23)$

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=48.05, p<0.001, MSE=.001, ηp2=.67, occupation M= .11 vs. gender M= .02. Main effect of CSI was not reliable F (2, 23) =3.00, p=.06, MSE=.01, ηp2=.11, 150 ms (M= .06), 700 ms (M=.08), 1000 ms (M=.05). None of the interactions were reliable: Task x Trial x CSI F (2, 23) =0.48, p=.62, MSE=.001, ηp2=.02; Trial x CSI F (2, 23) =0.24, p=.78, MSE=.001, ηp2=.01; Task x CSI F (2, 23) =3.00, p=.08, MSE=.001, ηp2=.10; Task x Trial F (2, 23) =1.52, p=.23, MSE=.00, ηp2=.06.

## III. Experiment 2: Gender and Emotion Task Switching

### a) Method

#### i. Participants

24 postgraduate students (13 female and 11 male, ages 22-25 years, M= 23.08 years) took part solely in experiment 2.

Materials, displays, procedure and analysis were same as Experiment 1 except the tasks were explained as emotion (happy/neutral) and gender (male/female). A manual response was made to the face by pressing keys on the key board: 1=male, 2=female, 3=happy, 4=neutral.

### b) Results

#### i. Reaction Times

Mean RTs were submitted to ANOVA with trial (switch vs. repeat) x task (emotion vs. gender) x CSI (150 vs. 700 vs. 1000 ms) as within subject factors. The main effect of trial was significant F (1, 23) =144.00, p<0.001, MSE=22478.86, ηp2=.86, switch (M=969 ms) repeat (M=757 ms). There was a reliable main effect of the task F (1, 23) =24.06, p<0.001, MSE=2420.06, ηp2=.51. RTs were faster on emotion than the gender task (M=849 vs. 877 ms). Main effect of CSI was significant F (2, 23) =34.51, p<0.001, MSE=23943.14, ηp2=.60, CSI 150 ms M= 955 ms, CSI 700 ms M= 864 ms, CSI 1000 ms= 770 ms). There was a significant interaction between Trial x CSI F (2, 23) =6.36, p<0.01, MSE=16483.27, ηp2=.21 (CSI 150 ms M= 260 ms, CSI 700 ms M= 208 ms, CSI 1000 ms M= 167 ms). There was a significant interaction between Trial x Task F (1, 23) =6.78, p<0.05, MSE=2155.20, ηp2=.22. The switch cost for gender task was larger than for the emotion task (M=226 vs. 198 ms; t (23) = 2.60, p<0.05). The interaction between Task x CSI was not reliable F (2, 23) =.08, p=.92, MSE=2111.55, ηp2=.00. Similarly, the higher order interaction between Trial x Task x CSI was not significant [F (2, 23) =.45, p=.63, MSE=5441.76, ηp2=.01, Fig.2].

### c) Errors

Mean errors were submitted to ANOVA with trial (switch vs. repeat) x task (emotion vs. gender) x CSI (150 vs. 700 vs. 1000 ms) as within subject factors. None of the main effects was reliable: trial F (1, 23) =0.54, p=.46, MSE=.04, ηp2=.03, switch (M= .12) repeat (M= .09); task F (1, 23) =0.42, p=.51, MSE=.00, ηp2=.01, emotion (M= .10) gender (M= .11); CSI F (2, 23) =0.47, p=.62, MSE=.00, ηp2=.02, 150 (M= .13), 700 (M= .10), 1000 (M= .09). Interactions were not significant: task x trial F (1, 23) =0.98, p=.33, MSE=.00, ηp2=.04; task x CSI F (2, 23) =0.93, p=.39, MSE=.00, ηp2=.03; trial x CSI F (2, 23) =0.03, p=.96, MSE=.00, ηp2=.00; trial x task x CSI F (2, 23) =0.30, p=.74, MSE=.00, ηp2=.01.

## IV. Experiment 3: Occupation and Emotion Task Switching

### a) Method

#### i. Participants

24 postgraduate students (ages 22-25 years, M= 23.54 years) took part exclusively in experiment 3. Materials, displays, procedure and analysis were same as Experiment 1 except the tasks were explained as emotion (happy/neutral) and occupation (actor/singer). A manual response was made to the face by pressing keys on the key board: 1=actor, 2=singer, 3=happy, 4=neutral.

### b) Results

#### i. Reaction Times

Mean RTs were submitted to ANOVA with trial (switch vs. repeat) x task (emotion vs. occupation) x CSI (150 vs. 700 vs. 1000 ms) as within subject factors. The main effect of trial was significant F (1, 23) =240.50, p<0.001, MSE=81405.36, ηp2=.91. RTs were slower on switch (M=1268 ms) than on repeat (M=747 ms) trials. There was a reliable main effect of the task F (1, 23) =147.40, p<0.001, MSE=15379.02, ηp2=.86. RTs were faster on emotion than the occupation task (M=919 vs. 1096 ms respectively). Main effect of CSI was significant F (2, 23) =35.47, p<0.001, MSE=173889.53, ηp2=.60. RTs were faster with long CSI (CSI 150 ms M= 1199 ms, CSI 700 ms M= 978 ms, CSI 1000 ms M= 845 ms). There was a significant interaction between Trial x CSI F (2, 23) =15.81 p<0.001, MSE=40886.99, ηp2=.40, CSI 150 ms M= 637 ms, CSI 700 ms M= 521 ms, CSI 1000 ms M=405 ms]. There was significant interaction between Trial x Task F (1, 23) =6.37, p<0.05, MSE=6008.25, ηp2=.21. The switch cost for occupation was larger than the emotion task t (23) = 2.52, p<0.05, M= 544 vs. M=498 ms respectively. The interaction between Task x CSI was not reliable F (2, 23) =1.60, p=.21, MSE=14754.08, ηp2=.06. The higher order interaction between Trial x Task x CSI was not reliable F (2, 23) =1.11, p=.33, MSE=7559.61, ηp2=.04, Fig.3.

### c) Errors

Mean errors were submitted to ANOVA with trial (switch vs. repeat) x task (emotion vs. occupation) x CSI



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(150 vs. 700 vs. 1000 ms) as within subject factors. The main effect of the task was significant F (1, 23) =23.00, p<0.001, MSE=.07, ηp2=.49. Errors were higher on occupation than the emotion task (M=.06 vs. .03). The main effect of trial was not reliable F (1, 23) =1.28, p=.26, MSE=.01, ηp2=.05, switch (M=.04) repeat (M=.05). Main effect of CSI was not significant F (2, 23) =1.41, p=.25, MSE=.00, ηp2=.05, (CSI 150 ms M= .04, CSI 700 ms M= .06, CSI 1000 ms M= .04). None of the interactions were significant Task x Trial F (1, 23) =.09, p=.75, MSE=.00, ηp2=.00; Task x CSI F (2, 23) =1.05, p=.35, MSE=.00, ηp2=.04; Trial x CSI F (2, 23) =1.24, p=.29, MSE=.00, ηp2=.05; Task x Trial x CSI F (2, 23) =2.00, p=.18, MSE=.00, ηp2=.07.

## V. Discussion

This study showed an asymmetric switch costs between different face categorizations. In experiment 1, gender categorization was faster than the occupation categorization. Occupation categorization yielded larger switch costs than the gender categorization. In experiment 2, emotion categorization was faster than gender categorization. Gender categorization produced larger switch cost than the emotion categorization. In experiment 3, emotion categorization was faster than the occupation categorization. The occupation categorization had larger switch costs than the emotion categorization. These results supported the first hypothesis of the study. Emotion is processed automatically (Vuilleumier et al., 2001). It captures attention and produces rapid brain response (Whalen et al., 1998) while face gender is not categorized automatically (Quinn, Mason, & Macrae, 2009). Neuropsychological studies suggest that emotion and identity categorization depend on distinct processes (e.g., Humphreys, Donnelly, & Riddoch, 1993). Emotion categorization relies on occipital to superior temporal stream with an activation in amygdala while gender categorization involves occipital to inferotemporal stream with an active contribution of the anterior temporal regions (Haxby, Hoffman, & Gobbini, 2000). As a result switch cost is emerged, however the magnitude of the switch costs differ across different pairings of face categorizations. The task-set of the difficult task takes longer to be configured than the task-set of an easier task. Difficult task suffers in switching conditions and yield a larger switch cost.

The switch cost was reduced with larger CSI. Our results supported the second hypothesis of the study. These findings are consistent with previous studies (Kiesel et al., 2010) demonstrating that sufficient preparation results in shorter switch costs. However, it is important to note here that the preparatory mechanism operates equally across emotion and non-emotion attribute of the faces, therefore emotional expressions of the faces are not special beneficiaries of this mechanism. These results have implications for understanding of pathological behaviour, as for example, task switching is difficult in patients following frontal lobe damage (Stablum et al., 2000). The present work demonstrated that executive control in task switching can be improved with sufficient preparation. This has implications for training more generally and specifically for individuals with executive dysfunctions and prosopagnosia.

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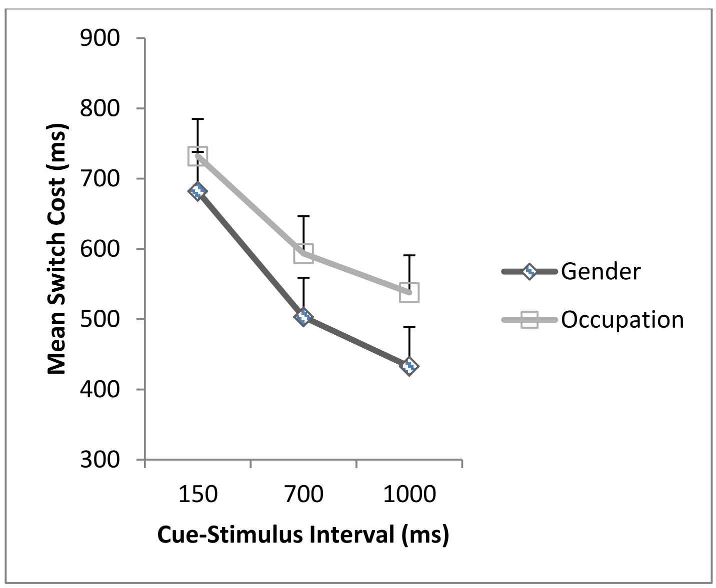


*Figure 1 :* Mean switch costs for the gender and occupation tasks with cue-stimulus intervals.



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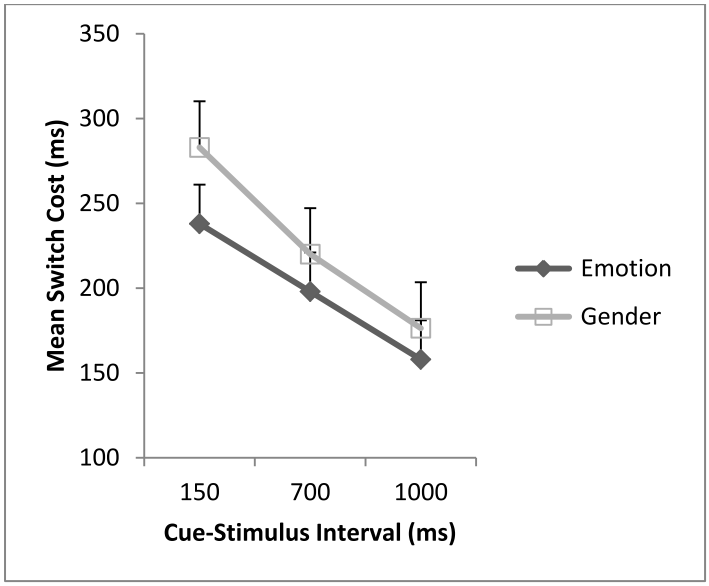


*Figure 2 :* Mean switch costs for the emotion and gender task with cue-stimulus intervals.

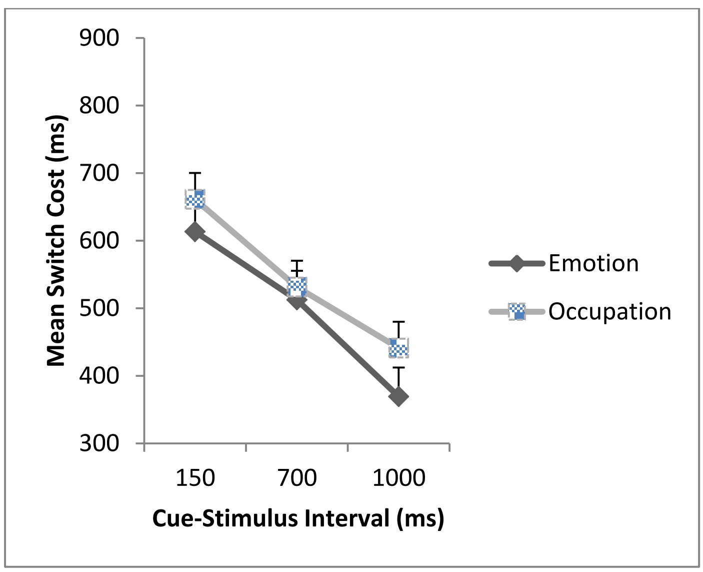


*Figure 3 :* Mean switch costs for the emotion and occupation tasks with cue-stimulus intervals.



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