

Adult Prospective Memory and Executive Function Performance: A Cross-Cultural
Comparison of Chinese and Canadian College Students

by

Julie (I-Chu) Chang

B.A., University of British Columbia, 2009

A Thesis Submitted in Partial Fulfillment
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in the Department of Psychology

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Supervisory Committee

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Abstract

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Prospective memory (ProM) is the ability people use to realize earlier-formed intentions at a delayed time. It has been proposed to be heavily reliant executive functions, as it shares many of its characteristic attributes, including working memory as well as planning and organizational abilities. Cross-cultural literature on executive functions (EF) has previously established evidence of advanced executive functioning in East Asian children when compared to age- and educationally-matched Western counterparts. Given the close association between ProM and EF, it is surmised that East Asians may also display an advantage in this specific memory type, and that this trend would continue into early adulthood when cognitive abilities typically have matured. Therefore, the goal of the present study was to investigate whether or not Mainland Chinese adults would display the same advantage in ProM when compared to Canadian adults. Analyses indicated that the Canadians did show significant disadvantage in ProM performance despite similar executive-functioning performances. The ProM findings are discussed in terms of potential psychometric inequity but also include accounts of cultural distinctions in neural and visual processing. The contradictory results in EF and ProM are explained in relation to socio-cultural differences and limitations in the present study design.

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Introduction

Prospective memory (ProM), defined as the ability to remember and execute an earlier-formed intention, is one of the most essential cognitive functions in our daily lives. Remembering to carry out a variety of goals and tasks such as picking up bread on the way home and doing laundry are everyday tasks that require prospective memory. Without this ability, it would be almost impossible to carry out the future necessary activities of living. Despite its importance, prospective memory remains a relatively unexplored area in cognitive science, especially so when compared to its retrospective counterpart (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). In addition, although other types of cognitive functions, such as planning and organizing, have been suggested to play an important part in this type of memory, perhaps more so than in retrospective memory, very little is known about the mechanics of this relationship. Unlike retrospective memory, a particular challenge in succeeding in prospective memory tasks is that the individual must remember the earlier-formed intention while engaging simultaneously in other activities. This feature of prospective memory makes it more susceptible to failures, and renders it to be one of the most prevalent everyday memory problems for even healthy individuals (Terry, 1988).

Stages of Prospective Memory

Prospective memory is an active and complex set of cognitive process that occurs in four stages (Martin, Kliegel, & McDaniel, 2003; McDaniel & Einstein, 2000): First, a plan is formulated (intention formulation); second, a delay period occurs during which the intention is retained while the individual is engaged with other background tasks irrelevant of the main intention (retention interval); third, the intention is recalled under

the appropriate context and time (intention initiation); and finally, the original intention is performed and evaluated (intention execution). These four stages can be applied to all of the three major types of prospective memory: Event-based prospective memory, time-based prospective memory, and activity-based prospective memory. The three types are distinguished mainly by the types of cues used to signal the appropriate moment to initiate the action. Event-based prospective memory requires a specific external stimulus to remind the individual to execute the intention (e.g., see your friend and deliver a message). Time-based prospective memory requires the individual to initiate and execute a previously-planned intention at a specific time (e.g., at 8 a.m., remember to bring out the garbage for collection) or within a specified time range (e.g., remember to pay and mail the bills tonight). Activity-based prospective memory requires the individual to perform a specific action upon the completion of another task (e.g., switching off the radio after you finish listening to a program). It is similar to event-based prospective memory task in that the appearance of an external cue prompts the retrieval of the intention. However, what differentiates it between the other two types is that it is considered to be less effortful due to the natural extension the conclusion of an immediate prior activity allows, making it non-intrusive to the progression of daily events (Shum, Ungvari, Tang, & Leung, 2004).

The many processes involved in prospective memory, such as forming intentions, interrupting and inhibiting responses, monitoring ongoing situations, and adjusting goals to respond flexibly to environmental changes, are all relegated to the domains of executive functions (EF). EF is an umbrella term for cognitive processes including planning, attention, working memory, problem solving and reasoning, inhibitory control,

and mental flexibility. Existing studies indicate that individuals with executive function impairments have pronounced deficits in memory-related abilities commonly attributed to the frontal brain region, such as organizing and carrying out the intended actions (Kliegel et al, 2006; McDaniel et al., 1999). Therefore, it is widely believed that prospective memory is primarily mediated by executive functions (Martin et al., 2003). Because time-based prospective memory requires self-initiation to carry out the action, it has been suggested that it demands more executive resources than its event-based and activity-based counterparts, where the external cues are present and serve to remind the individual of the task (Einstein & McDaniel, 1990; Nater et al., 2006). Although the research in this area is not yet conclusive, that prospective memory relies more on executive functions than retrospective memory appears to be the general consensus (Kliegel, Jäger, Altgassen, & Shum, 2008; Zinke et al., 2010). In the present study, I investigated all three types of prospective memory.

Developmental Trajectory of Prospective Memory

Prospective memory ability is evident in the early stages of life. Research suggests that event-based prospective memory is present in children as young as three years old (Guajardo & Best, 2000), while time-based prospective memory is suggested to emerge around elementary-school age when children began to acquire a more sophisticated understanding of the concept of time (Wang, Kliegel, Yang, & Liu, 2006). The additional executive demands placed on the individual when utilizing the complex mechanisms required to succeed in time-based prospective memory – such as continuous monitoring – also supports the theory of delayed mastery (Martin, Kliegel, & McDaniel, 2003). Both types of prospective memory have been shown to be continuous developing

as individuals mature cognitively and become increasingly proficient at using external sources to aid prospective remembering (Wang et al., 2006). Current literature offers at least two lines of evidence that support the notion of increasingly advanced prospective memory performance up to early adulthood. First, the development of neural structures assumed to be integral to prospective memory does not arrest in adolescence. Executive functions such as inhibition, planning, working memory, and self-initiation that are crucial to prospective memory depend on neural structures that are observed to be in a constant flux of change and maturation across adolescence (McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999). Frontal lobe regions, the area associated with executive functions, have been shown to have elevated activity during prospective memory tasks (e.g., Benoit, Gilbert, Frith, & Burgess, 2011; Burgess, Quayle, & Frith, 2001). Several studies have demonstrated myelination, neurotransmitter characteristics, and other late structural changes in the frontal lobe, with some progressing into early adulthood (e.g., Benes, 2001; Sampaio & Truwit, 2001). Based on the research review, Wang et al. (2006) suggested that the adolescents' retrieval proficiency in prospective memory may still pale in comparison to young adults.

Second, researchers have suggested that other memory abilities, including working memory, which is vital to prospective memory (Martin et al., 2003), continue to evolve during childhood (e.g., Luciana, Conklin, Hooper, & Yarger, 2005). A study conducted using Chinese university and junior high students demonstrated the age-dependent efficiency of event-based prospective memory (Wang et al., 2006), which supports the reasoning that this memory ability continues to improve across adolescence and into early adulthood. Following this line of reasoning, it is plausible to conjecture

that cognitive performances not limited to executive functions, but also prospective memory, may still evince growth in the adult stages of life, or at least in early adulthood.

Cultural Influences on Development of Executive Functions

Developmental differences in executive functions are the result of multiple factors. With the increase in age, so do executive function abilities improve (Davidson, Amso, Anderson, & Diamond, 2006). Executive functions are not only impacted by the natural effects of age and developmental maturation, but environmental settings as well. Growing evidence from research indicates that cultural differences can be expressed beyond that in language and values, but also through basic cognitive processes. Earlier studies (e.g., Campbell & Xue, 2001) have demonstrated that cultural backgrounds can have a profound impact on mental resources such as working memory and cognitive flexibility (i.e., mathematics). Differences in performance for such tasks are observed between Chinese and North Americans even before elementary period (e.g., Siegler & Mu, 2008). Cultural differences in executive functions have also been discovered and, not surprisingly, this effect is found at a young age (Sabbagh, Xu, Carlson, Moses, & Lee, 2006). When comparing the performance on measures of executive functions, Sabbagh et al. (2006) detected differences between the preschoolers in China and the United States: indeed, Chinese preschoolers had a significantly better performance than those in the US on tasks of executive functioning including response inhibition, working memory, and other related cognitive tasks. A recent study using a slightly older population observed similar results (Zhan et al., 2011). Zhan and colleagues conducted a study in which a sample of Chinese children aged 8 to 10 years old were given a maintained attention (vigilance) task, an ability that is simultaneously called upon when engaged in many

cognitive functions. Although the differences were modest (within one standard deviation), possibly due to the fact that the task difficulty was too high for children in this age range, the results did demonstrate that when Chinese children were measured against a comparable British sample (Wilding & Cornish, 2007), they showed slower performance but with fewer false alarms. With regards to the contributing factors, it has been suggested that sociocultural factors, such as differential emphases on education or self-regulation in school, may have played a role in influencing the development of cognitive abilities (Blair & Razza, 2007). For example, performance on working memory has been shown to be influenced by school-related experiences from as early as prekindergarten and kindergarten, while response inhibition skills can be affected by prekindergarten schooling experiences (Burrage, Ponitz, McCready, Shah, Sims, Jewkes, & Morrison, 2008). A study by Burrage and colleagues (2008) examined working memory and response inhibition improvement following a period of approximately one school year in prekindergarten and kindergarten. Schooling effects were separated from non-schooling experiences and typical age-related development by the matriculation deadlines set by the school, which arbitrarily divided children born in the same year into those who were either born before the date or delayed in months. Because of this, the two groups of children included in the study were similar in chronological age but had entirely different schooling experiences. Results of this natural experiment mirror another done a decade earlier in which better short-term memory performance was observed in children who were attending first year elementary than those in kindergarten in both the fall and spring term (Morrison, Smith & Dow-Ehrensberger, 1995). Similar findings from other research combine to suggest that executive function processes do indeed benefit

from effects of education and/or school-related experiences. While influences from the extra-familial care as well as from the greater number of peer interactions in the academic environment might have contributed to facilitating the rate of acquisition of executive skills, the results appear to be more in line with the differential schooling and culturally-specific instructions. Sabbagh and colleagues (2006) found that unique culturally-related influences in early instructions, emphasis and expectations of patterns of executive functioning between the Chinese and American may have yielded the findings. Specifically, it has been proposed that cultural practices play a monumental role in promoting an individual's capacity for self-regulation (Oh & Lewis, 2008). Compared to their American counterpart, the Chinese are expected to master their impulse control from a much younger age – as early as two years old (Chen et al., 1998) – and this trait is much more highly valued and encouraged in the preschool settings of the latter (Tobin, Wu, & Davidson, 1989). Indeed, behavioural inhibition and self-restraint are considered signs of social maturity and mastery of the self according to Confucian philosophy, which is stressed in traditional Chinese education. This may explain the results of the study cited earlier on performance in tasks measuring selective attention and attention maintenance (Zhan et al., 2011). Unlike Western cultures, the Chinese society values and positively regards cautiousness, inhibition, and self-restraint (Chen, Rubin, & Li, 1997). It may be this differential cultural encouragement to be more reserved that resulted in these children reacting more cautiously, thus leading to a lower false alarm frequency. Recalling the study by Sabbagh et al. (2006) that demonstrated Chinese children have more mature levels of executive functioning when compared to age-matched American children, despite similar theory-of-mind and verbal abilities, it may be conjectured that

this is at least part of the consequence of the greater stress placed upon educational training as well as the comparably more restricted time devoted to recreational activities than in Western cultures (Parmar, Harkness, & Super, 2004). Qualities such as discipline, effort, perseverance, and deferred gratification are ingrained cultural values that have been cited as factors to which the Chinese students own their impressive achievements (Li, 2001; Yang, 2007). Continued efforts, rather than innate abilities, are often credited as the key to (academic) success (Okagaki, 2001). Culturally-reflective emphases such as these dictate the contents of the curriculums taught in the Chinese school system. Specifically, lessons are structured in a way which instils propriety in behaviour. Through daily use of planning tools such as family agendas that indirectly teach organizational and planning skills as well as cultural imbuelement on self-regulation and control, Chinese students may become more proficient at carrying out goal-directed activities, a focus of executive functioning. With the increase in age and practice, these skills may become more elevated, thereby facilitating and enhancing executive control. By the time the children reach adulthood, these culturally-based advantages may manifest themselves more prominently in skills that demand these cognitive functions, such as prospective memory.

So far, only a few studies have investigated the differential cultural and educational influences on the development of executive functions, and none of them has linked themselves to the study of prospective memory. Development of this memory skill is arguably a major feat in an individual's cognitive maturation (Meacham & Colombo, 1980). As abovementioned, existing studies advocate that its development begins early around the preschool- and primary-school age (e.g., Wang et al., 2006) and continues

simultaneously as an individual's executive function matures and the individual becomes more skilful at utilizing external cues to aid their prospective memory retrieval and execution (Meacham & Colombo, 1980). These functions, which include the ability to resist impulsivity, to sustain attention in order to complete tasks, and to switch focus depending on changing task demands, are important executive-functioning mechanisms that regulate future-oriented behaviour; as they mature, so do presumably prospective memory skills. However, findings have not shown consistent cross-cultural synchronies in cognitive development. It is therefore not clear whether there would be any noticeable advantages or disadvantages in adult prospective memory skills across two representative samples from traditionally-regarded antithetical cultures of East and West, namely the Han-Chinese and European-descent Caucasians. Research has documented the degree to which intensive learning experiences in Asia can improve thinking skills and memory, such as superior mathematics performance (e.g., Stevenson, Lee, & Stigler, 1986), and this appears to be largely the fruit of specific instructional practices and parental expectations (Stevenson et al., 1990); as well, recent findings suggest that associated academic abilities may be largely accounted for by proficiency in self-regulation – inhibitory control in particular (Blair & Razza, 2007). The maturity in cognition can be manifested in abilities that include proficiency in working memory, inhibition, and cognitive flexibility (Davidson et al., 2006), all of which are central to prospective memory. Although there is some evidence that culturally-based advantages manifest at an early age (e.g., Sabbagh et al., 2006), this study will explore whether culturally-based difference exist within the adult population. The choice seems logical given the evidence that executive functions do not reach their full maturation until early adulthood (Luciana

& Nelson, 2002; Lyons-Warren, Lillie, & Hershey, 2004; Zelazo, Craik, & Booth, 2004). Since different measures of performance reflect the inconsistent developmental rates of underlying cognitive processes (Wilding & Cornish, 2007), by utilizing an adult sample composed of individuals in the age range of the zenith of their cognitive maturity and functioning, the results are less likely to be impacted by young-age effects. In line with the cultural upbringing and differential educational emphases, I predicted that the Chinese students would have particular advantages in their executive control, thereby strengthening their prospective memory abilities. I hypothesized that because the Chinese students have more culturally-defined opportunities to exercise and practice executive-functioning skills than their Canadian counterparts, they would be more advanced in this area, in turn giving them an advantage in their prospective memory performance. While various research studies corroborate the age-long theory that the environment has an important impact on the development of cognitive and executive skills, how much unique contributions both schooling and non-schooling developmental experiences have in shaping them is still an unknown. An extensive literature review found no studies that directly compared the executive functioning and prospective memory of the Chinese and Canadian adults. Thus, an important question addressed in the present study is whether prospective memory is indeed superior in the Chinese relative to the Canadian students, and, if so, whether this relationship can be explained by differences in executive function, and finally whether those differences are due to cultural influences.

In summary, the purpose of this study is to examine prospective memory performance in adult students attending local universities in China and Canada. It was predicted that memory performance would follow this pattern: The Chinese students

would have better prospective memory than their Canadian-Caucasian counterparts and that this performance would be correlated with and explained by differential executive functions.

Specific Hypotheses

The two main hypotheses derived from this study are as followed: 1) Chinese students would outperform the Canadian-Caucasian students on the computerized prospective memory tasks, 2) Prospective memory performance would correlate with the executive-functioning tasks. To examine these hypotheses, both subjective and objective measures used in two studies previously conducted in China meant to establish the relations between executive skills, subjective reports, and prospective memory, were employed. If schooling and differential cultural emphasis do play a role in shaping the cognitive development of the students, then I would expect there to be differences in not only executive functioning and prospective memory, but also in the participants' approach and perception of how to best handle the tasks. Therefore, in addition to measuring the adults' cognitive performance, I included two subjective measures. This not only allowed self-evaluations of everyday memory failures and successes, but also adds to the ecological validity not available with laboratory paradigms. I expected that the Chinese students would show more precaution and attention in handling the tasks, consistent to the cultural encouragement to be cautious and behaviourally inhibited. More specifically, on tasks of executive function, the Chinese participants were expected to make fewer errors. These differences were expected to be observed in not only objective tasks, but subjective reports as well: The Chinese participants would judge themselves as exhibiting less common cognitive failures. The present study addressing these issues

contributes to not only informing a cross-cultural theoretical account of the relation between executive functions and prospective memory, but also sheds light on the potential benefits of differential schooling experiences.

Methodology

Participants

Participants from different ethnic groups, totalling eighty-three post-secondary students, were recruited from the combination of institutions in China and Canada. The Chinese students were recruited from Peking University, Sun Yat-Sen University, Guangdong Vocational College of Mechanical and Electrical Technology, and Zhongkai University of Agriculture and Technology. This data was made available through an international collaboration with Dr. Raymond Chan, a professor in the Institute of Psychology of Chinese Academy of Sciences in Beijing, China. The original intent for this data was not cross-cultural, but provided an adequate number of college-age students performance on various measures of ProM and executive functions. The Canadian students were recruited from an undergraduate psychology research pool at the University of Victoria in British Columbia. The students in both countries were given both objective and subjective measures of executive functions and prospective memory. The prospective memory tasks were based on the measures employed by Wang and colleagues (Wang et al., 2008), who have adopted a comprehensive assessment of all three types of prospective memory tasks, originating from research in cognitive psychology. Executive-function measures included two working memory tasks (a Letter-Number Span Test and an N-Back). Self-report measures included the Prospective and Retrospective Memory Questionnaire (PRMQ) and the Dysexecutive Questionnaire

(DEX). Chinese equivalence versions of the questionnaires were translated from the original English versions and developed for the purposes of previous studies, with earlier research findings revealing satisfactory reliabilities and validities despite language modifications (as cited in Chan et al., 2008b, p. 233). Data for the Chinese students come from two separate studies conducted four years ago (Chan et al., 2008b; Wang et al., 2008). There were twenty participants from the first study (Wang et al., 2008), which included nine males and eleven females from Peking University and Sun Yat-Sen University ($M = 22.70$ years, $SD = 4.88$). Twenty-eight Chinese participants were taken from the second study (Chan et al., 2008b). Participants from the Chan et al. (2008b) study consisted of nine males and nineteen females ($M = 23.93$ years, $SD = 7.77$) recruited from Peking University, Sun Yat-Sen University, Guangdong Vocational College of Mechanical and Electrical Technology, and Zhongkai University of Agriculture and Technology. The thirty-five Canadian students were recruited solely for this comparative study and were all Canadian-born Caucasians of European descent who were taking undergraduate psychology courses at the University of Victoria, British Columbia, Canada. Like the Chinese sample, participants were accepted into the study by structured questionnaires screening out individuals with known neurological illnesses or alcohol/drug dependence, and have family histories of psychiatric illnesses. Participants were further selected on the basis that they were right-handed and had normal or corrected vision. The demographic data of the participants are shown in Table 1.

Table 1
Demographic and WAIS Descriptive Statistics

	Chinese (<i>N</i> = 42) Mean (SD)	Canadians (<i>N</i> = 35) Mean (SD)	<i>p</i>
Age (years)	21.64 (1.48)	20.74(1.69)	.99
Education (years)	14.55(2.02)	15.29(1.36)	.07
Gender (male: female)	15:27	11:24	.70
WAIS Arithmetic ¹	11.57(3.24)	9.06(1.96)	.00
WAIS Digit Span ¹	14.21(2.81)	10.57(2.08)	.00
WAIS Similarities ¹	10.50(3.32)	10.83(2.09)	.61

¹scaled scores

p < .01 are bolded

Intellectual functioning for all participants was estimated by three subtests (Arithmetic, Similarities, and Digit span) from the Weschsler Adult Intelligence Scale-Revised (WAIS-R); the Chinese group was administered the Chinese version of the WAIS-R as adopted by Gong (1992). The two ethnic groups were matched on age and educational levels. For the Canadian group, the tasks were administered in their native/primary language, English. For the Mainland Chinese, the tasks were presented in Mandarin or Cantonese. Verbal and written consent were obtained from each participant before proceeding with the study.

Prospective Memory Measures

Three computer-based prospective memory tasks, based on dual-task paradigms by Einstein and McDaniel (1990), were implemented to capture all three subtypes of the memory: Event-based, time-based, and activity-based. The background or ‘ongoing task’ (OT) meant to occupy the retention intervals were divided into semantic and perceptual conditions for both event- and time-based prospective memory. The activity-based prospective memory task was presented at the end of all four prospective memory conditions.

The semantic *event-based* prospective memory task differed for the Chinese versus English speakers as there was no ‘clear’ equivalent English task to the one that had been completed by the Chinese students. For the Chinese students, the OT was the presentation of four-character Chinese phrases. The translated phrases can be found in Appendices A and B. The participants were required to indicate whether or not the stimuli were Chinese idioms by pressing the “J” key to answer affirmatively, and the “F” key to answer negatively. The target (ProM) task required the participants to press the

spacebar on the keyboard when the Chinese phrase contained an animal word (e.g., tiger), and to refrain from responding to the OT. The animal words appeared five times during the entire trial, with approximately 1-min intervals between each appearance. The ongoing distractor task had 88 trials, and participants were told that in completing the task it was equally important to respond correctly for both the OT and the target task. The target animal stimuli were horse, tiger, mouse, chicken, and fish. For this Chinese version, the words were selected from a list considered as appearing in high frequency in the language (Zhang, 2005) and the idioms were recognized as official by the Committee of Idiom Dictionary (2004).

Given that idioms are not as culturally significant for Canadian students, I created what I proposed to be an equally engaging and demanding English task. The Canadian students were presented with English short phrases and were asked to judge whether or not they were grammatically correct. As in the Chinese version, the target ProM task was to press the spacebar when the phrase contained an animal. The same number of animal words as in the Chinese version was used in the task, spaced in the same duration sequence. The phrases were simple sentences composed with a subject or pronoun, modifier, verb, and object. Punctuation was eliminated to minimize difference between the Chinese and English version. Identical to the Chinese version, the ‘J’ and ‘F’ keys for affirmative or negative responses were used. There was no need to respond to the OT when the opportunity to engage in the target task arose simultaneously.

For the OT of the semantic conditions, I opted to have English-speakers evaluate whether or not the sentences were grammatically sound rather than judging whether or not they were common expressions or idioms for three reasons: First, there were no

English equivalents for many of the Chinese expressions, and the English-speakers would not recognize them as idioms; second, it was not possible to reconcile the nuances derived from translations between languages. Even if the interpretations were accurate, some of the longer sentences would prove difficult to read and comprehend in the short time span they appeared on the computer screen; finally, unlike the Chinese educational system, there is an absence of lessons on English proverbs and/or idioms in the Canadian school curriculums.

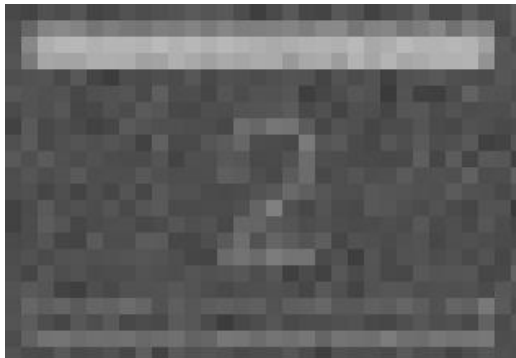
The Canadian version of the semantic stimuli was created by following the described procedures: First, an online sentence generator (<http://www.manythings.org/rs/>) that produced sentences with specified terms (e.g., subject + adverb + verb + object) generated short sentences (e.g., Patricia quickly fried an egg). Second, a bilingual (Chinese-English speaker) modified the sentences to induce a grammatical error for each one (e.g., Patricia quickly fried a egg). Third, the sentences were screened by two native English speakers who provided feedback/recommendations for changes (in Appendix C).

For both groups, all of the stimuli were presented in white fonts on black screen. They appeared for 1500 milliseconds (ms) each and were followed by a black screen with a random duration time of either 1500 ms, 2000 ms, or 2500 ms. All the instructions for this task were presented to the participant on the screen before beginning the task.

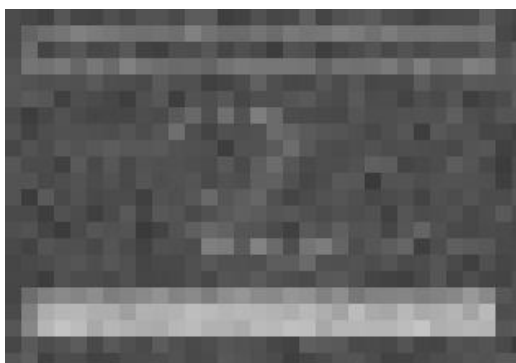
The semantic *time-based* task was essentially the same as the *event-based* described above, except a digital-clock readout, visible to the participants at all times throughout the task, was placed beside the computer screen. Participants were asked to press the spacebar at the start of every minute (as marked by the 00 second on the clock). No animal names were in this task, which consisted of 90 trials.

In the perceptual *event-based* task, a digit (between 0 and 9) was presented to the participants in a perceptually-degraded manner and they were asked to judge whether or not the digit presented was a 0, pressing ‘J’ if they thought so, and ‘F’ if they thought it was not. The digit was sometimes shaped irregularly, but was always presented between two bars that were situated above and below it. The participants were instructed to search for a down arrow (defined as the ProM task) (see *Figure 1*) while engaging in the ongoing distractor task, but were told to regard both tasks as equally important. Upon seeing a down arrow, the participants were required to press the spacebar despite whether or not the digit is 0. Each digit remained on the screen for 300 ms and was followed by a blank screen with a random duration time of 1500 ms, 2000 ms or 2500 ms. There were 122 trials for the ongoing distractor task and five for the target prospective memory task, with the same number of time intervals in between as the semantic task. All instructions for this task were presented to the participant on the screen before beginning the task.

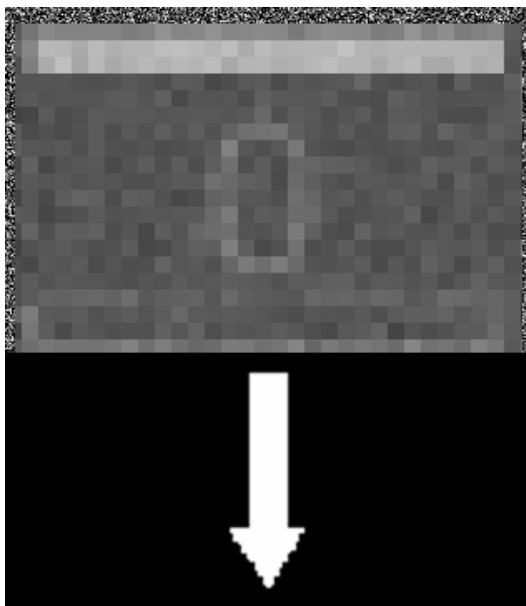
Figure 1 (a) Regular digit in perceptual ProM tasks



(b) Irregular digit in perceptual ProM tasks



(c) ProM cue in perceptual ProM tasks



The perceptual *time-based* prospective memory task was similar to its semantic counterpart in that a digital clock display was presented to the participants, who were asked to monitor it and press the spacebar when it arrived on each minute. However, the OT was to determine whether or not a vague computerized digit was 0 using the same key press as the perceptual *event-based* condition. There were no down arrows in this task. For convenience of reference, Table 2 shows a list of the English tasks and their respective target tasks and key-presses.

Each of the sessions lasted approximately five minutes. Before each experimental session began, there was a practice period consisting of 10 sample trials in which the instructions were presented visually and aided by verbal clarifications. It was also during this period that the participants were given the instructions about the activity-based prospective memory tasks. At the end of each task, participants saw a note indicating its end and thanking them for their participation. Upon seeing it, they were told to press the “Enter” key to completely “exit” the program. Participants received one point for each activity-based prospective memory task success, resulting in a total of four possible points.

Table 2
Prospective Memory Tasks and Conditions

	Ongoing Task (key press)	Target Task (key press)
Semantic		
Time-Based	Verify grammatical-correctness of phrase <i>'j' for correct / 'f' for incorrect</i>	Note 1-minute lapse <i>spacebar</i>
Event-Based	Verify grammatical-correctness of phrase <i>'j' for correct / 'f' for incorrect</i>	Find animal word <i>spacebar</i>
Perceptual		
Time-Based	Determine whether or not number is zero <i>'j' for yes / 'f' for no</i>	Note 1-minute lapse <i>spacebar</i>
Event-Based	Determine whether or not number is zero <i>'j' for yes / 'f' for no</i>	Find down-arrow <i>spacebar</i>
Activity-Based	-	Note end of task <i>enter</i>
	-	

Note. All tasks described are for the English version

Executive Function Measures

Working Memory (Wang et al., 2008)

To assess the participants' working memory capacity, they were administered a computerized N-back task, based on a paradigm used by Callicott, Ramsey, Tallot et al (1998). The present study employed four digits (2, 4, 6, 8) appearing in four separate circles on the screen. The digits appeared one at a time in a fixed cycle. For the 0-back condition, the participants needed to press a key corresponding to the digit they had just seen as quickly as possible. For the 1-back condition, the participants needed to press a key corresponding to the digit they had seen previous to the most immediate one. For the 2-back condition, the participants needed to press a key corresponding to the digit they had seen previous to the last two presented. Each digit appeared on the screen for 400 ms, and then disappeared for 950 ms. Digits appeared in a pre-fixed pseudo-random order.

In addition to the N-back task, the participants were administered a Letter-Number Span Test (LNS). The task entailed the participants to listen to digits 1 to 9 mixed with letters of the English alphabet. In both versions, immediately afterwards, participants were asked to repeat the stimuli with the digits first then the letters, all arranged from smallest to biggest or in alphabetical order. For the Mainland students, they were also administered a Chinese equivalence version of the Letter-Number Span Test was developed by Chan et al. (2008a). Participants were read to verbally digits 1 to 9 mixed with Chinese characters (in a specific sequence, such as A, B, C in English). Later, they were asked to repeat what was heard but in the order so that the digits, that come first, would be arranged first from small to big, and then the characters, in sequence.

Prospective and Retrospective Memory Questionnaire (Chan et al., 2008b)

The Prospective and Retrospective Memory Questionnaire (PRMQ; Smith, Della Sala, Logie & Maylor, 2000) is a 16-item, self-report measure of common, everyday prospective and retrospective failures. There are 8 items for each memory type. The items were designed to have an equal number of inquiries about self-cued and environmentally-cued memory, as well as short-term and long-term memory. Each question is rated on a 5-point scale that indicates the frequency of everyday memory failures, from “never” to “very often”. Reliability is 0.92 for the total scale, 0.87 for the Prospective Memory Scale, and 0.83 for the Retrospective scale (Crawford, Henry, Ward, & Blake, 2006).

Dysexecutive Questionnaire (Chan et al., 2008b)

To assess common cognitive concerns, all participants were administered the Dysexecutive Questionnaire (DEX) developed by Wilson, Alderman, Burgess, Ermsley, and Evans (1996). The 20-item questionnaire allows the participants to rate the frequencies of characteristic executive failures, such as problems with abstract thinking, impulsivity, confabulation, and planning. Each question is scored on a 5-point scale ranging from “never” to “very often”. Previous studies suggest that it has good psychometric properties and clinical discrimination. Factor analysis showed that there are five factors to the DEX: inhibition, intentionality, executive memory, positive affect, and negative affect (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). The Chinese students were administered the translated versions used in previous studies (Chan, 2001; Chan & Manly, 2002), which is suggested by findings from Chan (2001) to have similar factors to the Burgess’ study: inhibition (e.g., “I find it difficult to stop doing something even if I know I shouldn’t”), intentionality (e.g., “I have difficulty thinking ahead or

planning when undertaking a task or activity”), knowing-doing dissociation (e.g., “I will say one thing, but then do something different”), in-resistance (e.g., “I find it hard to stop repeating, saying or doing something once started”), and social regulation (e.g., I lose my temper at the slightest thing”). The Chinese version was first used by Chan (2001) and was administered to 93 normal participants along with several other neuropsychological tests. Correlation was then explored between the tests, and comparisons were made to the five factor solution proposed by Burgess et al. (1998), with results arriving at similar conclusions as the previous studies in English.

Procedure

Canadian participants were recruited through the Psychology Department Subject Pool. They were verbally briefed about the study and were given the opportunity to clarify any questions during the consenting process. Each one signed a consent form before proceeding to the questionnaires and cognitive measures, ending with the computerized tasks. Instructions for all of the computerized tasks can be found in Appendices D to G.

As the Chinese participants were from two separate studies, they had not all been administered the same cognitive tasks, depending on the group they were in; however, all Chinese participants had received the identical prospective memory tasks and underwent the intelligence assessment using the WAIS-R. From the study by Wang et al. (2008), the participants were given only the working memory tasks (LNS & N-Back). From the study by Chan et al. (2008b), participants were given the two questionnaires (PRMQ & DEX). The Canadian sample were administered all the cognitive tasks and questionnaires utilized in the two previous studies with Chinese samples.

Results

Unless specifically mentioned, all analyses were performed on raw data.

Preliminary Analyses

Seven participants from the Chinese group were dropped from analysis due to that their age did not fall within the acceptable range used for selecting the Canadian students (18-25 years old). The Arithmetic (Chinese: $M = 11.57$, $SD = 3.24$; Canadians: $M = 9.06$, $SD = 1.96$) and Digit Span scaled score (Chinese: $M = 14.21$, $SD = 2.81$; Canadians: $M = 10.57$, $SD = 2.08$) of the Chinese and Canadian samples significantly differed, $t(75) = 4.20$, $p = .00$; $t(75) = 6.36$, $p = .00$. The Similarities standardized scores were nearly identical (Chinese: $M = 10.50$, $SD = 3.32$; Canadians: $M = 10.83$, $SD = 2.09$), $t(75) = -.53$, $p = .60$. Therefore, Digit Span and Arithmetic were applied as covariates in our analyses to ensure that the main effects of country could not be attributed to, or obscured by, effects of other abilities such as the abovementioned. As well, because of the large discrepancies between cultural groups in the response times (RT) of the semantic ongoing tasks, in which the Canadian students took significantly more time than the Chinese in both the time-based ProM ($t(75) = -17.55$, $p = .00$) and the event-based ProM ($t(75) = -12.57$, $p = .00$), RT was controlled for in the prospective memory analysis. For the LNS, although the Chinese completed another version in their native language, because there was no difference between that and their English performance for both the total number of correct items, $t(78) = .29$, $p = .77$, or for the longest-item passed, $t(78) = .32$, $p = .75$, for comparative purposes only the data for the English version was used.

Prospective Memory

Table 3 summarized the following analyses. A multivariate analysis of covariance (MANCOVA) with the standardized scores from the two WAIS-R subtests and the RT of the semantic conditions as covariates revealed significant main effect of group in the time- and event-based ProM tasks, $F(4, 68) = 12.86, p = .00$; partial $\epsilon^2 = .431$. (Pillai's Trace). Follow-up univariate Group analyses of covariance (ANCOVAs) showed that except for Semantic Time-based ProM in which there was no difference in performance, the Chinese group significantly outperformed the Canadians in the other three tasks.

Two separate MANCOVAs were conducted to analyze cultural differences in the response time and accuracy of the ongoing tasks. Results showed that there was a significant main effect of group, $F(4,70) = 54.84, p = .000$; partial $\epsilon^2 = .77$. (Pillai's Trace) for RT, but not for OT accuracy: $F(4,70) = .87, p = .49$; partial $\epsilon^2 = .047$. No group difference was found between the RT of the perceptual conditions, but with regard to the semantic conditions, the Canadian group was found to be significantly slower than the Chinese group for both the Time-based ProM task, $F(1, 73) = 171.09, p = .00$; partial $\epsilon^2 = .70$ as well as the Event-based ProM task, $F(1, 73) = 83.58, p = .00$; partial $\epsilon^2 = .53$.

For the Activity-based Prospective Memory task, a Pearson's chi-square was conducted and showed a significant association between the cultural group and whether or not students succeeded after the completion of precedent ProM tasks: Semantic event-based ($\chi^2(1) = 13.00, p = .00$); Semantic time-based ($\chi^2(1) = 12.58, p = .00$); Perceptual event-based ($\chi^2(1) = 12.58, p = .00$); Perceptual time-based ($\chi^2(1) = 16.10, p = .00$). The Chinese students were found to succeed more often in all four opportunities to complete this task than the Canadian students.

Table 3
Cultural Comparison of Memory Tasks

	<u>Chinese (N = 42)</u> Mean (SD)	<u>Canadian (N = 35)</u> Mean (SD)	<i>F</i>	<i>p</i>	η^2/χ^2
Semantic					
Time-Based-ProM	.81(.29)	.29(.32)	.06	.81	.00
Time-Based-OTA	.84(.06)	.78(.10)	2.00	.16	.03
Time-Based-OT RT	971.56(192.95)*	1749.46(193.50)*	171.09	.00	.70
Activity-based ProM	.88(.33)	.51(.50)	-	.00	12.58
Event-based-ProM	.86(.16)	.55(.31)	9.27	.00	.12
Event-based-OTA	.85(.08)	.82(.08)	.56	.46	.01
Event-based-OT RT	1015.90(247.43)*	1683.82(213.07)*	85.56	.00	.54
Activity-based ProM	.90(.30)	.54(.51)	-	.00	13.00
Perceptual					
Time-Based-ProM	.93(.13)	.25(.26)	44.44	.00	.39
Time-Based-OTA	.90(.05)	.91(.06)	.12	.73	.00
Time-Based-OT RT	557.22(84)*	584.65(100.21)*	.37	.55	.00
Activity-based ProM	.95(.22)	.57(.50)	-	.00	16.01
Event-based-ProM	.84(.24)	.77(.31)	8.68	.00	.11
Event-based-OTA	.92(.04)	.86(.25)	.96	.33	.01
Event-based-OT RT	601.78(103.56)*	632.59(79.81)*	.19	.67	.00
Activity-based ProM	.88(.33)	.51(.51)	-	.00	12.58

OTA = Ongoing task accuracy; OT = Ongoing task; RT = Response time; * = Milliseconds

$p < .01$ are bolded

Executive Functioning

The following analyses are summarized in Table 4.

DEX and PRMQ scores were standardized and analyzed with multivariate analysis of covariance (MANCOVA). Results showed an insignificant main effect of group, $F(3,55) = .94$ $p = .43$; partial $\epsilon^2 = .05$ for the following categories: DEX (Total Score) and PRMQ (Prospective component and Retrospective Component). Individual DEX Factors derived from the analysis of Chan (2001) were analyzed separately and showed a significant main cultural effect: $F(5,59) = 5.14$ $p = .00$; partial $\epsilon^2 = .303$. However, separate ANCOVAs revealed that only Factor 4 (in-resistance) differed between groups: $F(1,63) = 7.03$ $p = .01$; partial $\epsilon^2 = .10$.

LNS scores (Longest Item Passed and Total Correct) were also standardized and analyzed with a separate MANCOVA which revealed a significant main effect, $F(2,70) = 4.16$ $p = .02$; partial $\epsilon^2 = .11$. Follow-up univariate analyses revealed that the groups differed in the LNS Total Correct, $F(1,71) = 7.21$ $p = .01$; partial $\epsilon^2 = .09$, with the Chinese participants outscoring the Canadians.

Separate MANCOVAs were conducted for the N-back accuracy and its Response time (RT), and no differences were reported between the two culture groups for accuracy, $F(3,68) = 1.21$ $p = .31$; partial $\epsilon^2 = .05$, but main group effect was significant for RT, $F(3,67) = 9.96$ $p = .00$; partial $\epsilon^2 = .31$. Notwithstanding the similar accuracy in performance, univariate analyses of the RT for N-back task revealed that the Chinese group were observed to be slower than the Canadians on two of the three conditions: 0-back RT, $F(1,69) = 2.36$ $p = .13$; partial $\epsilon^2 = .033$; 1-back RT, $F(1,69) = 21.35$ $p = .00$; partial $\epsilon^2 = .24$; and 2-back RT, $F(1,69) = 18.86$ $p = .00$; partial $\epsilon^2 = .22$.

Table 4

Executive function and Working Memory Descriptive Statistics

	Chinese Mean (SD)	Canadians Mean (SD)	<i>p</i>
DEX Total ¹	23.38(10.19)	19.31(9.33)	.57
DEX-1 ¹	1.11(.54)	1.21(.62)	.90
DEX-2 ¹	1.43(.73)	1.22(.69)	.79
DEX-3 ¹	1.10(.59)	.90(.56)	.56
DEX-4 ¹	1.04(.63)	.60(.49)	.01
DEX-5 ¹	1.14(.66)	.83(.57)	.07
PRMQ-PM ¹	18.12(3.20)	18.49(3.80)	.37
PRMQ-RM ¹	15.62(4.33)	16.71(3.31)	.30
LNS Total ²	15.48(2.94)	15.03(2.74)	.00
LNS-LIP ²	6.03(1.03)	5.71(.89)	.24
N-Back 0 Accuracy ²	.83(.34)	.91(.24)	.90
N-Back 1 Accuracy ²	.66(.31)	.69(.24)	.08
N-Back 2 Accuracy ²	.49(.26)	.45(.20)	.56
N-Back 0 RT ²	425.89(192.88)	415.79(128.84)	.13
N-Back 1 RT ²	629.11(226.00)	481.04(169.71)	.00
N-Back 2 RT ²	641.45(184.48)	412.09(180.56)	.00

¹Chan et al., 2008b; ²Wang et al., 2008

DEX = Dysexecutive Questionnaire; DEX-1 = Inhibition; DEX-2 = Intentionality; DEX-3 = Knowing-Doing Dissociation; DEX-4 = In-Resistance; DEX-5 = Social Regulation; PRMQ-PM = Prospective and Retrospective Questionnaire, Prospective Memory Component Score; PRMQ-RM = Prospective and Retrospective Questionnaire, Retrospective Memory Component Score; LNS Total = Letter-Number Sequence Total Number Correct; LNS-LIP = Letter-Number Sequence Longest Item Passed

p < .05 are bolded

Relationship between Prospective Memory and Executive Functioning

Two separate standard multiple regressions were used to assess the contributions of Working Memory Tasks and Self-ratings to ProM task performance. The working memory tasks and self-rating scores were standardized, and mean accuracy of the N-back tasks was combined into one average score. In both analyses, the combined average score of the semantic and perceptual ProM tasks were used as the dependent variable. When working memory tasks were entered as predictor variables, it was found that neither measure was significant. The overall model fit was $R^2 = .051$. Using PRMQ ProM Component and DEX Total Score as predictor variables showed that only the latter was significant ($\beta = .324, p = .03$). The overall model fit was $R^2 = .123$. When separate DEX Factors were used as predictor variables, it was found that Factor 1 (inhibition) and Factor 4 (in-resistance) were significant: $\beta = -.425, p = .00$; $\beta = .339, p = .04$. Overall model fit was $R^2 = .197$. The specific results are shown in Table 5.

Finally, correlations between all measures of ProM and executive functioning are provided in Tables 6 and 7.

Table 5

Correlations between Prospective Memory, Working Memory, and Self-Ratings

	All participants ($N = 77$)			
	B	SE B	β	p
DEX Total	.080	.037	.324	.03
DEX-1	-.105	.036	-.425	.00
DEX-2	.016	.039	.066	.67
DEX-3	-.009	.042	-.035	.84
DEX-4	.084	.039	.339	.04
DEX-5	.051	.038	.205	.18
PRMQ-PM	-.060	.048	-.241	.22
LNS Total	-.001	.047	-.002	.99
LNS-LIP	.056	.048	.228	.24
N-back	-.002	.029	-.008	.95

B = Unstandardized beta coefficient; SE B = Standard Error; β = Standardized beta coefficient; DEX = Dysexecutive Questionnaire; DEX-1 = Inhibition; DEX-2 = Intentionality; DEX-3 = Knowing-Doing Dissociation; DEX-4 = In-Resistance; DEX-5 = Social Regulation; PRMQ-PM = Prospective and Retrospective Questionnaire, Prospective Memory Component Score; LNS Total = Letter-Number Sequence Total Number Correct; LNS-LIP = Letter-Number Sequence Longest Item Passed
 $p < .05$ are bolded

Table 6
Correlations among WAIS-R Subtests, Prospective Memory Tasks, and Executive Functioning Measures

	Arithmetic	Digit Span	PRMQ Total Score	DEX Total Score	LNS Total Correct
Arithmetic	-	-	-	-	-
Digit Span	.568**	-	-	-	-
PRMQ Total Score	-.166	.023	-	-	-
DEX Total Score	.068	.238	.499**	-	-
LNS Total Correct	.486**	.400**	-.013	-.058	-
N-Back 0	-.283*	-.203	-.120	-.036	-.145
N-Back 1	.321**	.102	.120	-.151	.206
N-Back 2	.357**	.189	-.009	-.072	.065
SetiOTA	.288*	.391**	-.113	.051	.206
SetiProM	.480**	.528**	-.255*	.040	.300**
SeevOTA	.112	.128	-.231	-.093	.187
SeevProM	.149	.291*	-.083	.133	-.014
PetiOTA	-.078	-.088	-.059	-.064	.063
PetiProM	.404**	.535**	-.214	.121	.131
PeevOTA	.015	.155	.057	.022	.076
PeevProM	-.082	-.044	-.054	.013	.014

**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level; PRMQ = Prospective and Retrospective Questionnaire; DEX = Dysexecutive Questionnaire; LNS = Letter-Number Sequence; Seti = Semantic Time-Based Task; Seev = Semantic Event-Based Task; Peti = Perceptual Time-Based Task; Peev = Perceptual Event-Based Task

Table 7
Correlations among Prospective Memory Tasks and Computerized Working Memory Tasks

	SetiOTA	SetiProM	SeevOTA	SeevProM	PetiOTA	PetiProM	PeevOTA	PeevProM
SetiOTA	-	-	-	-	-	-	-	-
SetiProM	.356**	-	-	-	-	-	-	-
SeevOTA	.517**	.343**	-	-	-	-	-	-
SeevProM	.240*	.410**	.239*	-	-	-	-	-
PetiOTA	.325**	.030	.439	.079	-	-	-	-
PetiProM	.418**	.637**	.195	.556**	-.060	-	-	-
PeevOTA	.513**	.221	.376**	.421**	.437**	.185	-	-
PeevProM	-.054	.043	.241*	.335*	.350**	.090	.256*	-
N-back 0	-.041	-.086	-.100	-.213	.018	-.232*	-.019	-.014
N-back 1	.167	.095	.215	.028	.222	-.014	.154	.125
N-back 2	.166	.270*	.246*	.114	.193	.154	.124	-.046

**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level

Seti = Semantic Time-Based Task; Seev = Semantic Event-Based Task; Peti = Perceptual Time-Based Task; Peev = Perceptual Event-Based Task

Discussion

Findings from earlier studies consistently found a relation between cognitive functioning and the environment in which individuals were raised. Results from the current study demonstrate for the first time that this same pattern of performance is preserved in adulthood. It is striking to find such large discrepancies between the two cultural groups, in that the Chinese students evinced higher levels of functioning on all three types of prospective memory than their Canadian counterparts. Furthermore, the findings suggest that the underlying processes may be independent of working memory, which is particularly surprising, given that I have speculated how vital this very memory component is to prospective memory.

Cross-Cultural Differences in Prospective Memory

The Canadian undergraduate students' performance on prospective memory was clearly poorer than that of their age-matched Chinese counterparts. However, no differences were shown between the Chinese and Canadians in terms of their working memory tasks, which suggest other mechanisms of EF may have impacted prospective memory. As noted previously, this advantage in prospective memory may stem from socio-cultural factors. Before I am able to conclude a valid cultural difference in prospective memory abilities, it is necessary to note that there was some non-equivalence in certain tasks, and thus they may not have imposed the same cognitive demands on both groups. This is an especially important consideration given the response times of the Canadians were almost twice as long than those of the Chinese in the semantic conditions. This may reflect that the task of determining grammatically-correct phrases was more difficult than that of determining if something was an 'idiom'. Our English measure

required that the students judge whether short English phrases were grammatically correct, which were potentially very taxing to the Canadians. Indeed, this task demanded active processing of the sentences, whereas the idiom task relied primarily on retrospective memory of having learned these idioms from a young age. In fact, based on the slower response times, one may even argue that the OT for this particular prospective memory condition may have imposed too much demand for the Canadians, leading to the poor performance observed. As such, the psychometric equivalence across cultures cannot be ascertained for this condition.

Nevertheless, the fact that all of the activity-based ProM tasks and the ProM tasks in the perceptual conditions showed a similar significant main effect of culture does lend credence to the observed results being true differences in ProM. Adding to the credibility is the fact that the semantic event-based ProM task was still observed to be significant even after controlling for the response times of the condition. Unlike the semantic tasks, the perceptual and the activity-based tasks retained the same instructions as the original Chinese, and all participants confirmed understanding and were given opportunities to clarify any misinterpretations before commencing. As such, there do not appear to be reasons to question the psychometric equivalence of those conditions.

Although congruent with the hypothesis, to find such poor prospective memory performances in the present sample of Canadian students is indeed still surprising. It is important to note that this is not consistent with previous findings from similar research using North American undergraduate populations, suggesting that the observed results may not be representative of Canadian students in general. Given this, subjective (motivational) factors need to be considered as having potentially contributed to the large

discrepancies between the current sample and other North American undergraduate samples. Previous research has shown that differential task emphasis can affect prospective memory performance in adults. For example, Kliegel and colleagues (Kliegel, Martin, McDaniel, & Einstein, 2001, 2004) demonstrated that stressing the importance of the prospective memory task component contributes to better performance, and suggests that the cause to be the volitional allocation of executive resources to the task elements. In the current study, the emphasis on the importance of completing the prospective memory task could not be the reason that the Canadian students performed more poorly than the Chinese students, as both groups received the same instructions and were reminded each time before the start of the practice trials that the OT and the prospective memory task were of equal importance. If task emphasis could influence the performance of prospective memory tasks due to the extra attentional resources devoted to its execution, then the results obtained could not be attributed to the conscious differential allocations of executive functions.

Another alternative explanation framed in the subjective approach has to do with the fair compensation that normally accompanies subject recruitment. Yet it is unclear how differences in the incentives could have caused such dramatically different results, as typically studies with undergraduate North American students also rewards students course credits in exchange for voluntary participation.

It is possible that if the critical factor is indeed subjective, it may be related to the attitudes the individuals held while undertaking the tasks. As deduced from the sociocultural arguments made in this paper, the Chinese may have been more intrinsically motivated to comply with the laboratory instructions and succeed in the tasks, whereas

the Caucasians did not approach the tasks with equal zeal. Behaviourally, the Chinese culture places a strong emphasis on social obligations; in contrast, Westerns are much more oriented to personal agency (Gutchess & Inneck, 2009), though this still would not explain the differences observed between the findings in my sample and other North American samples of undergraduate students. As such, I am cautious to note that I may have captured a subjective response to the tasks in my particular sample of Canadian students in which they were, in particular, less motivated to perform to their highest capacity.

The abovementioned implications of the present findings are echoed in previous studies. In studying the differences between underlying event-based ProM retrieval processes and that of underlying vigilance, Brandimonte and colleagues discovered that the reaction time in the ongoing task was systematically slower in the vigilance tasks (Brandimonte, Ferrante, Feresin, & Delbello, 2001). The accuracy of the ongoing task actually complemented the reaction time in that participants made more errors in the prospective memory conditions, which was not due to a speed-accuracy trade-off (Brandimonte et al., 2001). The authors explained that the results in terms of differences in the levels of conscious monitoring: Unlike vigilance tasks, prospective memory cues were retrieved automatically rather than actively, which granted more degrees of error-liability. Typically, a failure in a prospective memory task is attributed to memory, whereas a failure in a vigilance task is commonly regarded as attentional (Maylor, 1996). The short time-frame of our laboratory tasks prohibits us from denying that there is an element of vigilance in our prospective memory paradigms – that is, occasional monitoring was required to check when the target would appear. In executing event-

based prospective memory tasks, majority of the people would claim to simply wait for the occurrence of the target rather than checking frequently (as cited in Brandimonte, et al., 2001, p. 99). As such, if the Chinese students did put more effort in, it is possible that the tasks were turned into vigilance tasks, leading them to have the planned intention to be continuously maintained in consciousness, thereby enabling their success rates (though these success rates are not higher than those observed in other studies using North American students).

Adapting this conclusion to our current study, the poor performance of the Canadians still remains a mystery. If objective factors are involved, one plausible answer may lie in cultural differences in neural processing and visual orientations. A survey of current literature offers this objective perspective that may apply to the findings in our perceptual conditions. Results from studies on cross-cultural differences converge to support that East Asians attend to contextual information (e.g., backgrounds in complex scenes) more than Westerners, who tend to attend more to focal points and/or object-based cues (as cited in Gutchess & Indeck, 2009, p. 143). An earlier study also reported how East Asians were able to recall more information about background elements of a scene when compared to Westerners (Masuda & Nisbett, 2001). In relation to our study, we can surmise that the Chinese were able to allocate cognitive processes in a fashion balanced enough to handle both tasks with efficiency; on the other hand, the Canadians presumably required more effort to complete the background task which subsequently impaired their performance. This premise appears to be further supported by the longer response times observed in all prospective memory tasks undertaken by the Canadians. Even while discounting the semantic condition for reasons of potential psychometric bias,

a similar pattern was still observed in the perceptual condition in which attentional resources must be directed to include a larger area on screen where the ProM target would appear. In light that the Chinese reportedly are able to process the relationship between foreground and background objects to a greater degree than the European Caucasians (Goto, Ando, Huang, Yee, & Lewis, 2010), the current study design may have further awarded particular advantage to them in terms of *focality*. Specifically, in prospective memory retrieval, if the encoded features of the cue are consistent to the ones in the ongoing task, then it can be considered *focal* to the ongoing task (Scullin, McDaniel, Shelton, & Lee, 2010). Within my study, the designs in the conditions allowed differences in the conjoint nature of the ongoing and ProM tasks. In the semantic event-based condition, specific words were designated as the ProM cues and the ongoing task directed attention toward processing such features due to that they both required the semantic processing of words. In the perceptual condition, the ongoing task required processing of perceptual features in the ongoing task (i.e., digits) that did not stimulate the extraction of the originally encoded ProM cue features (i.e., downward arrow). The same logic in the perceptual event-based ProM task can be applied to the time-based ProM tasks in either condition, in that the ProM cue can be considered *nonfocal* due to the differential perceptual processing it required from the ongoing task. According to the multi-process theory, successful *nonfocal* ProM performance relies on monitoring for the cue, making it susceptible to interference (Scullin et al., 2010). Thus, the Chinese may have been better adapted to the current tasks by way of being able to better engage in attentional-demanding processes needed to detect *nonfocal* cues without compromising efficiency in the background task.

In contrast, the observation in RT is reversed in a task in which the background could be dismissed, namely the N-back that presented individual stimuli in a central location. Here, the Canadians were able to respond faster than the Chinese without losing their accuracy, which is consistent with the culture-specific framework that European Caucasians show more efficient neural processing of focal and target objects (Goto et al., 2010). Given these accounts, the greater holistic processing abilities of the Chinese may explain why they enjoyed higher success rates in the ProM tasks, while the Canadians exhibited faster response rates to tasks that favour efficiency in attention to foreground objects. Overall, it is possible that even if the differences observed in the current study are not purely subjectively-related, there are certain factors exclusively presented in this study – possibly neural/cognitive-based – that may have caused the results observed.

Cross-Cultural Differences in Prospective Memory in relation to Working Memory

The finding that the poor Canadian performance in prospective memory functioning were not mirrored by similar disadvantages in the working memory has important implications for explaining the relation between the memory types as well as the complex mechanisms in remembering to do things at a later time. This was clearly the case for the Canadian students in the present study, who showed nearly identical performance in the pure working memory tasks and only did more poorly in the prospective memory tasks. The reason for this is not readily apparent. Perhaps the most compelling evidence can be found in the literature that documented poorer prospective memory performance under situations of higher demand. Studies investigating the effects of increasing working memory demands of the ongoing activity on prospective memory load reveal that the latter is sensitive to competitive cognitive loads (Logie, Maylor, Sala

& Smith, 2004; West & Bowry, 2005). It was discovered that for younger adults (age range 18-21, which is comparable to the sample utilized in the present study), the success of prospective memory was related to the working memory demands of the ongoing task: Response accuracy data demonstrated that the N-back load influenced the frequency of prospective hits in younger adults, but not in older adults (West & Bowry, 2005). Interestingly, the observation is reversed when looking at how the prospective memory load affects the probability of a correct response for the N-back trials. Follow-up studies observed consistency in the findings that indicate an association between prospective cue detection and working memory demands (West, Bowry, & Krompinger, 2006). In reference to our study, although the perceptual and activity-based background tasks posed the same demands to the Canadian students, the addition of the prospective memory targets may have been too laborious to the participants. In support of this, the current results demonstrated that the Chinese outperformed the Canadian group in working memory as displayed in the Total Correct count in the LNS as well as the N-back accuracy in the high demand 2-back condition (albeit the latter is statistically non-significant). Though the findings from the present study regarding this topic is inconclusive, it is suspected that differential attentional allocation policies may have been adopted by the groups when faced with the concurrent challenges of performing a demanding working memory task while simultaneously anticipating the prospective targets. Looking at the RT alone, the Canadians were generally shown to be slower in responding to the ProM tasks' background targets, and that this difference is highly significant in the semantic condition, in which the OT presumably monopolized more cognitive resources than in the perceptual condition. Furthermore, when analyzing solely

the perceptual responses, even in this condition the Canadians were weaker than the Chinese on the ProM task. Upon closer inspection of its more effortful time-based task, it was evident that the Canadians, while performing the same as the Chinese in the OT, had much more difficulties in realizing delayed intentions. Corroborating research literature that time-based ProM is more strenuous than its event-based counterpart (e.g., Einstein & McDaniel, 1990; Nater et al., 2006), the cultural difference was even more pronounced in this task than in the event-based counterpart. A detailed survey of the data clearly revealed that the semantic condition would have replicated the results in the perceptual condition had not its RT was controlled. The findings appear to indicate that the attentional processes associated with successful prospective remembering are sensitive to concurrent working memory demands. More research is warranted to detail the factors contributing to the potential interfering effects of the concurrent task in realizing delayed intentions. Future extensions of our study could benefit from the addition of different OT and ProM targets with manipulated difficulty levels.

Self-Ratings

Interestingly, the Chinese group's self-ratings did conform partly to our hypothesis and rated themselves as experiencing more executive-functioning problems. Since I had hypothesized that the Chinese group's self-reports may be influenced by both culturally-imbued values as well as educational practices, this observation is certainly promising. The present study employed two different self-reports. The PRMQ asked participants the frequency to which they would forget certain actions that affects mainly the individual self; on the other hand, the DEX included questions that allow participants to assess themselves subjectively on actions that would also impact on others. From the

perspective of the collectivist Asian culture, it might be expected that the Chinese would be more humble, leading them to rate themselves less favorably in terms of general cognitive abilities. The same expectations were not held for the PRMQ due to the level of involvement prospective remembering is in their daily routines. This failure to find a significant difference in self-ratings may be attributed to problems of statistical power and small sample sizes. Though the present data did have enough power to show objective differences, the fact that only around half of the Chinese participants had self-measure scores to compare to the Canadians – unlike the ProM tasks that were completed by all participants – should not be discounted.

Limitations

The current study has a number of limitations. As outlined above, the English semantic trials may have imposed too much secondary demand to the participants and, as a result, the ProM accuracy in the condition may be a reflection of this rather than a display of true memory difficulty. In addition, only two measures were used to assess self-rated memory and EF failures, and both relied on frequency counts. Future studies should incorporate multiple self-rating tools that capture subjective responses involving more introspection and that are also better able to operationalize the variables. Inclusion of third-party ratings could be utilized to obtain a better picture of the everyday cognitive failures, for example. In the same fashion, a more varied – yet also stringent – selection of EF tasks should be implemented. With regard to the present working memory paradigms, the limited selection may not have allowed valid measures of individual differences. Specifically, the psychometric properties of the N-back task are not well known. Although the task appears useful for experimental research in working memory

and, particularly at higher load factors, well predicts inter-individual differences in other higher cognitive functions, at the same time it has been suggested that it has insufficient reliability in capturing individual differences in working memory (Jaeggi, Buschkuhl, Perrig, & Meier, 2010). Therefore, it would be wise to at least increase the load factors of the N-back (e.g., up to 3-back) if not expanding the working memory selection to include other measures. Finally, the designs of the current study could be improved by accentuating the difference between time-based and event-based ProM tasks, as it could be argued that the ProM cue of the current time-based ProM task does not clearly distinguish itself from that of an event-based paradigm. Therefore, employing a time-dependent design may be a potential modification.

Conclusion

The current study appeared to have yielded data that are consistent with the accumulating evidence that supports the analytic and holistic characterization of culture and cognition. Rather than construing the observed differences in a one-sided subjective or objective framework, perhaps the interplay between cultural self-construal and neural measures of cognition should be acknowledged when analyzing the results. It is important to note that the limited measures implemented in the study do not allow this to be more than a tentative interpretation. As such, the findings are in need of replication; the questions posed by the results should undergo empirical investigation adopting a more rigorous methodological design and utilizing a more diverse variety of laboratory paradigms modified to correct the present shortcomings.

Notwithstanding the limitations in the research design, the data did inspire ideas for future directions. Additional work is warranted to investigate if – and how –

concurrent task loads would produce a decline in the ability to recruit preparatory attentional resources that facilitate the processing of prospective cues. As well, the contradictory findings between executive functioning and prospective memory point to the need to continue this line of inquiry. Future study that further examines how cultural differences in executive functioning interact or facilitate prospective memory is the next stage in determining the social influences of this fundamental cognitive ability. Such investigations will lay a foundation for studying whether or not the ontogenetic link between cognitive functioning and environment could be preserved in adulthood, which will be especially beneficial to understanding the qualities of culture-specific learning and the potential advantages in acculturation.

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Appendix

Appendix A: Semantic condition, Chinese version Time-based ProM stimuli (#1-45 are idioms; direct translations or semantically-equivalent phrases are in italics)

1. *Safe and sound*
2. To make a guest feel as if she/he is at home
3. To have great patience and not to feel irked by an otherwise irritable situation
4. Describing amazement for an observation of a talent that could be considered not of this world
5. Fair and impartial
6. To manipulate with such ease as if the mind is one with the hands
7. Describing an individual with great integrity and dignity exuded from magnificent appearance
8. Sunny with gentle wind
9. Describing a clumsy state in which attending to one matter is causing negligence for another
10. To be honest and open without guilt of misdeeds
11. Describing extreme happiness and gladness
12. To have an epiphanic realization
13. To have broad knowledge and experience
14. *Subsequently; one after the other*
15. To achieve high standing on an exam with an evaluation report that is usually open to the public
16. *Organized, orderly*
17. *Unprecedented; never before in the history of time*
18. Describing an individual who is both like a good teacher and a beneficial friend
19. Describing a place with an allure that causes people revisit it again and again or leads people to forget the intention to return
20. To have an expression that exudes happiness like the spring breeze
21. To manage competently all areas and/or aspects
22. *Unfathomable ridiculousness*
23. *As easy as pie*
24. Describing a state of utmost concentration and attention
25. To have one's wish/desires satisfied
26. *Never before in history*
27. To do a task so efficiently as to allow easy progress and great rewards
28. To converse with a sense of humor akin to charm
29. *Forever and ever*
30. *Together for better or for worse*
31. To be beyond reach
32. *Worry-free; hakuna matata*
33. *Colorful; multi-coloured*
34. To describe a small, dainty item with evidence of delicate craftsmanship
35. *Willingly; full-heartedly*

36. To describe a state of confidence as if one has already half-completed the task
37. To sigh relief (usually after some sort of hardship/suffering)
38. *Smooth-sailing*
39. Describing difficulty in leaving something/someone due to yearning
40. To individualize teaching
41. A reminder to be always grateful, such as thanks for the source of the water one drinks
42. *It will not be long*
43. To be loyal; to have a loyal heart
44. To use circular-reasoning in one's lie/words
45. *A full-house*
46. *Patriotism*
47. *Safety glass*
48. Grey hair, evidence of age/past hardship
49. *Saving the list of plays*
50. *Defense attorney*
51. *Excuse-me*
52. Unmoved, untouched emotionally by present – often deploring – circumstances
53. *Color television*
54. Basic condiments/necessities of regular meals (e.g., oil, rice, etc)
55. *Spring, summer, autumn, winter*
56. *Beating/playing an instrument*
57. *To yell and scream*
58. *Mountain-climbing sport*
59. To pile in mountains
60. *More or less*
61. *To act without a second word*
62. Not accepting even a penny
63. *To assume one's post*
64. *Broadcast exercise*
65. *Sea creatures*
66. *In other words*
67. *Time/state of emergency*
68. So close as if just by the eye
69. *Life-saving grace*
70. *Forte; a defining talent*
71. *Line production*
72. Forehead covered in large drops of sweat
73. *Average profit*
74. Incredible/unlimited potential
75. Gaining the trust of citizens
76. *Crossroad*
77. Numerous, countless
78. *Track and field*
79. *Wireless phone*
80. *Interaction, interrelation*

81. Before-school education
82. *Accidentally, carelessly, without intent*
83. *Volunteer/volunteerism*
84. *For the first time in one's life*
85. To be both surprised and delighted
86. *Back and forth*
87. *Spaceship*
88. Organized
89. *Novel*
90. *Anyway; in summary*

Appendix B: Semantic condition, Chinese version Event-based ProM stimuli (#1-44 are idioms; direct translations or semantically-equivalent phrases are in italics)

1. To sigh and make a sound that signifies deep grief
2. To go against one's goal
3. Uncountable in numbers
4. *Warm spring, blossoming flowers*
5. Open and receptive to constructive criticisms
6. To be venerated, highly respected
7. *Forever and ever*
8. To gaze left and right
9. To face hardships together
10. Having a balance between strength and gentleness
11. Enigmatic, mysterious
12. *Never before, never more*
13. *Eye-catching glamorous/brilliance*
14. Under the public eye
15. *Gentle breeze, drizzling rain*
16. *To turn danger into naught*
17. To animate characters with such lifelikeness that it is like they have their own voice and expressions
18. Cannot wait
19. Extremely valuable
20. To be so shocking as to disturb the heavens and shake the earth
21. To be frank, open upon meeting
22. Describing a senior who is still strong in physical strength and/or spirit
23. To go back and forth with gifts; to respond in the same manner as the giver
24. To gaze upon something/someone with unmoving eyes
25. *Returning from the dead*
26. Describing something/something that can transform/change infinitely
27. *Bosom friends*; to have a tight-knitted relationship
28. Having a refreshed appearance
29. *Omnipotent*
30. To gain insight of the nature of something, and to act accordingly to it
31. *Shangri-la*
32. Finding out the truth
33. To react appropriately to unexpected situations
34. Describing a state of reasonableness; logical condition
35. To be one-hearted when facing difficulties/obstacles
36. *Innovation*
37. *Whole-wide world*
38. Describing a state of unexpected happiness/delight
39. To feel complacent/satisfied about one's actions; feeling good about one's doing
40. *Satisfied heart and goal*
41. Describing incredible happiness and excitement
42. *Sparkling clean/squeaky clean*

43. *Two birds with one stone*
44. *To fight for first out of fear of being the last*
45. *Closed-circuit television*
46. A type of red-colored sweet that is made of sugar-coated fruit
47. *Unrealistic*
48. *Long-distance bus*
49. *Other than this*
50. *Never before*
51. *See the forest for the trees*
52. *To make a scene*
53. *Narrative story*
54. *Developed country*
55. To obtain by illegal means
56. To be weathered
57. During the time of holidays and celebrations, such as the New Year
58. A steel bulwark; great wall of steel
59. *Microeconomics*
60. Public security/defense department
61. *Chinese ping-ying*
62. *Synchronized swimming*
63. *Minimal wage*
64. *Technical institution*
65. *Overtime*
66. *Empiricism*
67. Describing procrastination and indecisiveness; failure to solve after long time
68. *To be specific*
69. *Labor intensity*
70. Under the scorching sun
71. *On the other hand*
72. *Green plants*
73. *Quite the opposite*
74. The four Chinese arts
75. *As abovementioned*
76. *Fruit of success*
77. Under the setting sun
78. Novelty
79. Act of preserving the health
80. From the start of the year to the end
81. *Toddler education*
82. *At the same time*
83. Priority in the selection/acceptance of recruits and delegating duties accordingly
84. *Immediate family*
85. *Subjectivism*
86. *Natural rhythm*
87. *Comprehensive university*
88. Neighbours

Appendix C: Semantic condition, English version ProM stimuli (#1-44 are grammatically correct)

1. The child searches for his ball
2. The kind king was betrayed violently
3. There are circles on the poster
4. This flower will blossom quickly enough
5. You kindly helped Bob move yesterday
6. Society should pay respect to elders
7. The girl danced on the stage
8. He is looking around for someone
9. It sure was raining hard yesterday
10. The yellow fabric is very soft
11. She would like to keep secrets
12. There is no one like him
13. The diamond sparkles on her finger
14. We like the sun very much
15. The weather is quite nice today
16. The chef demonstrates his cooking skills
17. Do not cast judgement on him
18. The devastating earthquake left millions homeless
19. My students all love math problems
20. John and Jane are very intelligent
21. They swim slowly to the shore
22. Remember to eat at 2 o'clock
23. A man offends his jealous colleague
24. Please do close your eyes slowly
25. The terminator rises from the ashes
26. She changed her dress and shoes
27. The four children are playing together
28. Two immature adults fight over nothing
29. Doug is looking for his letter
30. Watch out for the scary monster
31. The green park is very beautiful
32. He bent the fork with effort
33. Everyone knows she is extremely smart
34. You can save a lot of money
35. We took the ferry to Victoria
36. Many people like to eat chocolate
37. The vast ocean is cold and blue
38. I am pleasantly surprised by you
39. Michel does not like cheese pizza
40. This child is not behaving properly

41. They like to write and draw
42. The entire house is squeaky clean
43. Three babies started to cry loudly
44. You are always afraid of clowns
45. The tv turn off like that
46. I likes to drink juice everyday
47. You guys aren't practical at all
48. He is very wasteful as person
49. She not love to play tennis
50. This phrase is grammatically correct sentence
51. Susan make pita bread like pro
52. We know Africa is large continent
53. This object be called a novel
54. Ben's new haircut look very ugly
55. The robber got away from police
56. The sun shines brightly on flower
57. Not cover your face is offensive
58. Country Y has always being free
59. The robot butler lost it's tie
60. My most favorite colors is red
61. He were being mean to infant
62. Sara plan to change her address
63. Its a big and pretty sweater
64. School is children go to learn
65. The accident left him crippled man
66. I of know him very well
67. This old book belongs to his
68. She is see someone right now
69. He was tire after today's work
70. The little boy runs and tripped
71. Sam and Adam doesn't get along
72. This computer is amaze to me
73. Opposites attracts each other like magnets
74. Heed the words wisdom by grandpa
75. Sarah went buy a purple purse
76. The little girl is skip rope
77. There are nothing new happening tomorrow
78. He have had a delicious burger
79. You say that this were fabulous
80. Too much people can be bad
81. Did you ate the refreshing salad
82. It is rain hard right now
83. He running fast like a car

84. My neighbours has always hated him
85. They bought a serum call "X"
86. I have never meet the diva
87. What wonderful day a today is
88. He said that he would ran
89. We says that we would go
90. A office worker buys a sandwich

Appendix D: Verbal Instructions for the Prospective Memory Tasks in the Semantic Condition

Hello. On the following screen you will see some sentences. Please determine whether or not each sentence is grammatically correct. If it is, press the 'J' key. If it is not grammatically correct, press the 'F' key. For example, sentences such as "Jimmy lives in a house" and "she goes to the store" are all grammatically correct, so you would press the 'J' key. On the other hand, sentences such as "Bob like play pool" would not be grammatically correct, so you would press the 'F' key.

For Time-based ProM Task, the following instructions were introduced: During the experiment, please pay attention to the clock placed before you. When the time comes to a full minute, please press the 'spacebar'. What we mean by a full minute is when the last two smaller digits turn '0', like this: 06:34:00

For Event-based ProM Task, the following instructions were introduced: Sometimes, embedded in the sentences, there will be some animal names, such as "Sara has a pet dog" or "Derek not like cats". At this time, irrespective of whether or not they are grammatically correct, you should press the 'spacebar'. There is no need to press 'F' or 'J' here.

Note: This task is as important as the task of judging whether or not sentences are grammatically correct.

Do you understand? If you have any questions, please ask them now. If you understand, press any key to continue.

Appendix E: Verbal Instructions for the Prospective Memory Tasks in the Perceptual Condition

Hello. You will see some ambiguous numbers appear on the following screen. For example (see top-right image):

Please determine whether or not this number is a '0'. If it is a '0', please press the 'J' key on the right. If it is not a '0', please press the 'F' key on the left.

For Time-based ProM Task, the following instructions were introduced: At the same time, please pay attention to the clock placed before you. When the time comes to a full minute, for example, '03:25:00', please press the 'spacebar'. You do not need to press 'F' or 'J' here.

For Event-based ProM Task, the following instructions were introduced: Sometimes, in the image, a downward-pointing arrow will appear. For example (see bottom-right image):

At this time, please press the 'spacebar'. You do not need to press 'F' or 'J' here.

Note: This task is as important as the task of determining whether or not the number is '0'.

Do you understand? If you have any questions, please ask them now. If you understand, press any key to continue.

Appendix F: Verbal Instructions for the Activity-based ProM stimuli

When the experiment is over and the phrases, “Thank you for your participation ^ _ ^
Goodbye!” appear, please press the ‘enter’ key to exit the program.

Appendix G: Verbal Instructions for the N-Back Tasks

For 0-Back: During the following experiment, numbers will appear inside the circles one at a time. When you see a number, please press the corresponding number key as fast as you can. When you see a '2', press '2'; when you see a '4', press '4', and so on.

If you have any questions, please ask them now. If you understand the instructions, please press the 'enter' key to begin.

For 1-Back: During the following experiment, numbers will appear inside the circles one at a time.

When you see a number, please refrain from pressing a key, but simply memorize it. When you see the second number appear, press the number key that corresponds to the first number as fast as you can; when you see the third number, press the number key that corresponds to the second number, and so on.

If you have any questions, please ask them now. If you understand the instructions, please press the 'enter' key to begin.

For 2-Back: During the following experiment, numbers will appear inside the circles one at a time.

When you see the first and second number, please refrain from pressing a key, but simply memorize them. When you see the third number appear, press the number key that corresponds to the first number as fast as you can; when you see the fourth number appear, press the number key that corresponds to the second number; when you see the fifth number appear, press the number key that corresponds to the third number, and so on.

If you have any questions, please ask them now. If you understand the instructions, please press the 'enter' key to begin.