PSYCHOLOGICAL SCIENCE

*Research Article*

# Limits on Introspection

## Distorted Subjective Time During the Dual-Task Bottleneck

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ABSTRACT—***Which cognitive processes are accessible to conscious report? To study the limits of conscious reportability, we designed a novel method of quantified introspection, in which subjects were asked, after each trial of a standard cognitive task, to estimate the time spent completing the task. We then applied classical mental-chronometry techniques, such as the additive-factors method, to analyze these introspective estimates of response time. We demonstrate that introspective response time can be a sensitive measure, tightly correlated with objective response time in a single-task context. In a psychological-refractory-period task, however, the objective processing delay resulting from interference by a second concurrent task is totally absent from introspective estimates. These results suggest that introspective estimates of time spent on a task tightly correlate with the period of availability of central processing resources.***

Even the simplest behavior involves a series of elementary cognitive operations. Intriguingly, the objective computational difficulty of these operations is often dissociated from their subjectively perceived complexity. For instance, the visual system efficiently and effortlessly performs complicated computations of which the observer remains unaware (e.g., invariant object recognition), yet people feel they struggle when solving simple arithmetic problems. Our goal in the experiments reported here was to begin to explore this dissociation by investigating which cognitive factors change introspective estimates of processing time, and which do not.

Ever since Wundt (1897/1999), the introspective method and the study of mental chronometry have followed distinct paths. Whereas the introspective method has led to the flourishing field of metacognitive research (introspection about mental content, feeling of knowing, etc.; see Nelson, 1996), chronometric studies have been most useful in dissecting elementary cognitive processes from an objective, third-person perspective (Posner, 1978, 2005). However, mental chronometry has largely left aside one of the founding questions of scientific psychology: What is the link between cognitive processes and conscious experience (Jack & Roepstrorff, 2003, 2004; Lutz, Lachaux, Martinerie, & Varela, 2002; Overgaard, 2006; Wundt, 1897/1999)? To address this issue, we designed a new methodology that we term *quantified introspection*. We engaged participants in standard response time (RT) experiments, but after each trial, we also asked them to give a quantitative subjective estimate of the time it took them to respond (introspective RT, or IRT). This enabled us to study the relation between objective RTs and introspective estimates of RTs, and thus to determine which processes contributing to RT are accessible to introspection and which are opaque.

A classical distinction separates early, effortless parallel processing and late, effortful central processing. Two-stage or global-workspace views of conscious access further stipulate that this distinction correlates with conscious accessibility: Only the second processing stage is accessible to conscious report (Baars, 1988; Dehaene, Kerszberg, & Changeux, 1998; Norman & Shallice, 1986; Posner, 1994; Shallice & Burgess, 1996). In the present study, we therefore sought to explore the prediction that IRT should be sensitive mostly to factors that affect central processing time. In Experiment 1, we used the classical additive-factors method (Sternberg, 1969) and studied a number-comparison task in which we manipulated two independent factors, number notation and numerical distance, which are known to affect RT in an additive manner (Dehaene, 1996; Pinel, Dehaene, Rivière, & LeBihan, 2001) and are thought to affect the perceptual and central stages, respectively (Sigman & Dehaene, 2005). In Experiment 2, we used the psychological-refractory-period (PRP) paradigm, a robust and widely used

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method for dissecting the perceptual and central stages (Pashler, 1994; Pashler & Johnston, 1989; Sigman & Dehaene, 2005; Smith, 1967).

## EXPERIMENT 1

### Method

The goal of Experiment 1 was to probe the reliability of the IRT measure, its relation to standard RT, and its dependence on experimental manipulations. We chose a well-studied number-comparison task, manipulating both the targets' notation (Arabic digits or number words) and their distance from the reference number, 45. Eighteen right-handed French speakers (mean age = 21 years, *SD* = 2) were asked to decide on each trial whether a single-digit number was larger or smaller than 45. All numbers from 21 through 69, except 45, were presented on a computer monitor either as Arabic digits or as number words. Participants indicated whether each target number was larger or smaller than 45 by clicking the right or left mouse button, respectively. After making this response to the number task, they indicated their introspective estimation of their RT (IRT) by using the mouse to click on a continuous graded scale that ranged from 0 to 1,200 ms and was labeled every 300 ms (see Fig. 1a). Participants were explicitly instructed to estimate the time between the

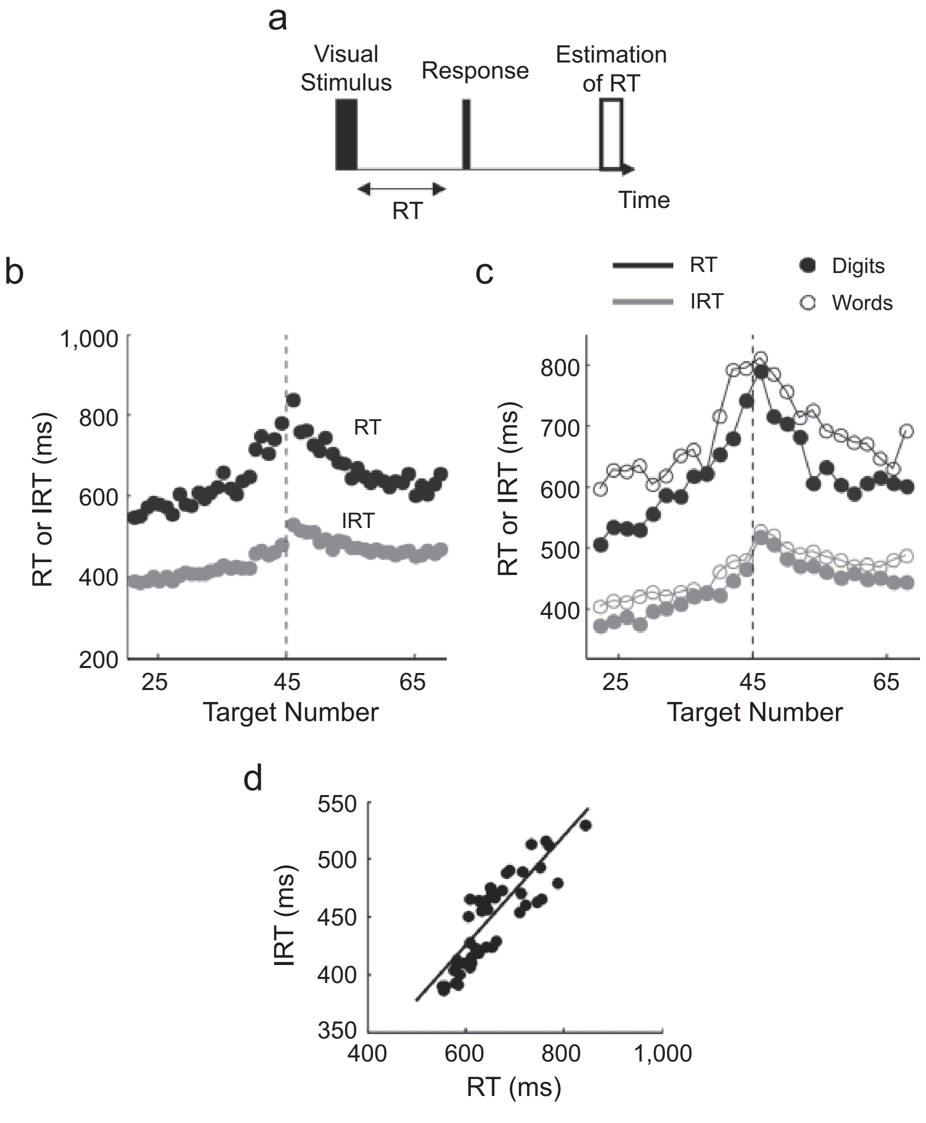

**Fig. 1.** Experiment 1: reaction times (RTs) and introspective reaction times (IRTs) in a simple number-comparison task. The display sequence is illustrated in (a). Numbers were presented as Arabic digits or as words. After comparing each number with a fixed reference (45), subjects estimated the time that they thought it had taken them to perform the task (IRT), using a continuous graded scale. The graphs present (b) RTs and IRTs as a function of distance from the reference (45), (c) RTs and IRTs as a function of both notation and distance from the reference, and (d) the correlation between RTs and IRTs across all numerical distances studied. In (b) and (c), the fixed reference (45) is indicated by the dashed vertical line.

appearance of the stimulus and the moment when they executed the response. They performed 20 practice trials before starting the experiment, but no feedback was provided to allow calibration within the temporal scale.

Stimuli were shown on a 17-in. monitor with a refresh rate of 60 Hz. Participants sat 1 m from the screen. Stimuli were always presented in the fovea, and their size was 1° for the Arabic digits and 2.5° for the spelled words. Participants performed a total of 384 trials, 192 trials with each kind of notation, sampled uniformly across all the possible target numbers.

### Results

Two subjects were excluded from analyses because they had unusually high error rates, above 15%. Only trials with correct responses were analyzed (94.4% of the trials). Mean RT was examined in an analysis of variance (ANOVA) with factors of notation (Arabic digits, spelled word) and distance (close numbers: distance $\leq 12$, far numbers: distance $> 12$). This analysis showed additive effects of the two factors (see Fig. 1c). As in previous studies (Dehaene, 1996), RT was affected by notation; mean RTs were slower for spelled words (690 ms) than for Arabic digits (609 ms), $F(1, 15) = 39.682$, $p_{\text{rep}} = .99$. RTs were also affected by the distance to the reference; mean RTs were slower for numbers close to the reference (707 ms) than for numbers far from the reference (592 ms), $F(1, 15) = 17.01$, $p_{\text{rep}} = .99$. There was no interaction ($p_{\text{rep}} < .64$) between these two factors.

We then investigated the effect of these experimental factors on IRTs and found an almost identical dependence. An ANOVA with factors of notation (Arabic digits, spelled word) and distance (close numbers: distance $\leq 12$, far numbers: distance $> 12$) showed additive effects of both factors (see Fig. 1c). IRTs were affected by notation; they were slower for spelled words (490 ms) than for Arabic digits (438 ms), $F(1, 15) = 14.452$, $p_{\text{rep}} = .98$. They were also affected by the distance to the reference; mean RTs were slower for numbers close to the reference (509 ms) than for numbers far from the reference (419 ms), $F(1, 15) = 8.75$, $p_{\text{rep}} = .92$. There was no interaction ($p_{\text{rep}} < .68$) between these two factors.

For the sake of simplicity, these ANOVAs treated distance categorically (i.e., far vs. close numbers). However, RTs and IRTs showed a similar functional dependence on distance, as Figure 1b shows. A linear decrease in RT as the log of the numerical distance increases is a classical result in number-comparison experiments (Dehaene, Dupoux, & Mehler, 1990; Moyer & Landauer, 1967). By showing that IRTs exhibit the same dependency, Experiment 1 demonstrates that the IRT measure provides a reliable subjective report that is tightly related to RT. To assess the reliability of this measure quantitatively, we studied the correlation between mean RT and mean IRT across the different numerical distances. Although IRTs systematically underestimated RTs, the two measures were very tightly correlated (see Fig. 1d). An analysis of correlation indicated that the slope of the regression of IRT on RT was positive for all 16 subjects ($M = 0.37$, $SD = 0.11$), and a $t$ test revealed that this slope was significantly different from zero, $t(15) = 12.7$, $p_{\text{rep}} = .99$, $d = 3.17$. The correlation coefficient between RT and IRT was also positive for all subjects (range = .45–.98, $M = .73$, $SD = .14$).

### Discussion

Experiment 1 establishes that IRT is a reliable measure, is tightly correlated to standard RT, and is sensitive to fine experimental manipulations. These results add to growing evidence that subjective reports are reliable and can be accurately quantified with an analog scale (Sergent & Dehaene, 2004). Additive-factors analysis showed additive effects of notation and distance on IRT, exactly as found for the standard RT. Moreover, across distances, RTs and IRTs were well correlated, which indicates that subjects can reliably estimate the time they took to accomplish a simple decision task.

However, the introspective estimates systematically underestimated the objective durations. In the linear regression analysis of RT versus IRT, the regression constants were positive, but also smaller than 1, for all 16 subjects. In addition, the $y$-intercepts were positive for 15 of the 16 subjects, which indicates that extrapolating these data to very short intervals leads to an overestimation. This contraction of estimated time—revealed in an underestimation of long intervals and an overestimation of short intervals—has been widely reported in objective temporal-interval estimations, and is known as Vierordt's law (Allan, 1979; Vierordt, 1868). However, conclusions regarding the absolute values of the estimates in this experiment are difficult because subjects were not calibrated to an objective temporal scale. In future studies, it will be interesting to investigate whether IRTs can be appropriately calibrated by first training subjects on the estimation of temporal intervals.

On the basis of dual-stage models and the hypothesis that conscious, effortful processing relates exclusively to central processing stages, we expected that the notation manipulation, which affected a perceptual stage of processing, might influence RTs without affecting introspective estimates of task duration. However, the data clearly falsified this expectation, as the notation manipulation significantly affected the introspective measure of RT. Thus, the results suggested that, under normal conditions of attention, subjects can attend to the duration of both perceptual and central processing stages as they unfold successively in the course of a task. The results left open the possibility, however, that perceptual stages become unavailable to introspection if participants' executive attention is distracted by another task. To further explore whether certain specific processing stages can be made unavailable to introspection, we conducted a PRP experiment in which dual-task interference reduced the availability of execution attention to the perceptual stage of a second task while the first task was being executed.

When two tasks are presented at a short interval, execution of the second task is systematically delayed (Pashler, 1994; Sigman & Dehaene, 2005, 2006; Smith, 1967). This interference effect is referred to as the PRP and has been explained by supposing that until a decision on the first target is reached, the second stimulus is buffered at a peripheral stage. According to this sequential model, the increase in RT to the second task when it is presented only a short interval after the first task is not related to additional processing at the central stage, but rather is due to a delay in the onset of the second decision process. Given our hypothesis that only central processing time is accessible to conscious report, we predicted that this delay may not be accessible to introspection, and that subjects would report that they processed the second task in the same amount of time, regardless of how closely spaced the two tasks were.

## EXPERIMENT 2

### Method

Fourteen right-handed Spanish speakers (mean age = 24 years, *SD* = 5) were asked to perform a dual-task procedure, with the clear instruction that they had to respond accurately and as quickly as possible to each task. Each trial involved an auditory (tone-discrimination) and a visual (number-comparison) task. The order of the tasks was fixed throughout the experiment: The first task was the tone-discrimination task, with pure tones presented through headphones. The tones were 150 ms in duration and had a frequency of 440 or 880 Hz. On each trial, subjects indicated whether the target tone had the low or high pitch. The second task was a two-digit number-comparison task with targets between 21 and 69, excluding 45. Each target was presented for 300 ms and had to be compared with 45. Across trials, the stimulus onset asynchrony (SOA) separating the tone and number targets varied randomly between 0 (simultaneous presentation) and 1,000 ms. Participants responded with their index and middle fingers of the left hand for the tone task and with the same fingers of the right hand for the number-comparison task.

After participants had responded to both tasks, they gave introspective estimates of the time they took to complete the tasks, using response screens identical to those in Experiment 1. Once they clicked to provide their introspective estimate of RT for the first task (IRT1), they saw a second, identical screen and gave their introspective estimate of RT for the second task (IRT2; see Fig. 2a). Great care was taken to emphasize that for both tasks, they had to report the time elapsed from the appearance of the relevant stimulus to the response.

Experiment 2 also included control blocks, in which participants received exactly the same stimulus sequence as in the dual-task blocks (i.e., a tone followed by a number at a variable SOA), but were asked to estimate the SOA between the visual and auditory stimuli, using the same continuous graded scale as in dual-task blocks (Fig. 3). Subjects performed five dual-task blocks of 32 trials and three control blocks of 32 trials, in random order. In the case of dual-task trials, we excluded trials with an incorrect response to either task ($<$ 20% of trials) and trials in which RTs exceeded 1,500 ms. We categorized numbers in the second task as "far" when their distance to the reference (45) exceeded 12 and as "close" otherwise.

### Results

We first report the RT results from the dual-task blocks, and then present analogous analyses of IRTs. Figure 2b shows RTs in both tasks (i.e., RT1 and RT2, respectively) as a function of SOA. These RTs exhibited a classical PRP pattern: Although RT1 was unaffected by the SOA, RT2 was longest for the shortest SOA and decreased to a plateau as SOA increased. These results suggest that the first task did not suffer from task interference, but delayed execution of the second task. For the second task, we coarsely identified an interference period (SOA $<$ 350 ms), during which performance was slowed down by the first task. On this basis, we categorized trials as interference trials (SOA $<$ 350 ms) and no-interference trials (SOA $<$ 350 ms). One-way ANOVAs showed a significant interference effect on RT2 (interference trials: $M$ = 819 ms, $SD$ = 26 ms; no-interference trials: $M$ = 620 ms, $SD$ = 27 ms), $F(1, 12) = 159$, $p_{\mathrm{rep}} = .99$. We refer to this difference in RT of almost 200 ms as the main PRP effect. In contrast, RT1 showed no interference effect (interference trials: $M$ = 570 ms, $SD$ = 15 ms; no-interference trials: $M$ = 594 ms, $SD$ = 21), $F(1, 12) = 4.50$, $p_{\mathrm{rep}} = .87$.

The classical model of the PRP (Pashler, 1994) predicts that factors affecting the perceptual stage of the second task, such as number notation, should be absorbed during the PRP "slack time" and therefore should not affect RT2 on interference trials; factors that affect the central stage, such as the distance between numbers, should affect RT2 on both interference and no-interference trials. We tested these predictions by submitting mean RT2 values to separate ANOVAs with SOA (no-interference: SOA $>$ 350, interference: SOA $<$ 350 ms) and either notation or distance as experimental factors (data were insufficient to perform a three-factor ANOVA). In the SOA × Notation ANOVA, notation (spelled words: $M$ = 735 ms, $SD$ = 26 ms; Arabic digits: $M$ = 702 ms, $SD$ = 24 ms) had a significant main effect, $F(1, 12) = 8.71$, $p_{\mathrm{rep}} = .97$, as did SOA, $F(1, 12) = 256.5$, $p_{\mathrm{rep}} = .99$. In addition, the interaction of notation and SOA was significant, $F(1, 12) = 17.1$, $p_{\mathrm{rep}} = .99$. In the SOA × Distance ANOVA, the main effect of distance was significant (far numbers: $M$ = 695.2 ms, $SD$ = 24 ms; close numbers: $M$ = 743.2 ms, $SD$ = 29 ms), $F(1, 12) = 34.6$, $p_{\mathrm{rep}} = .99$; as in the first ANOVA, SOA was significant, $F(1, 12) = 273.4$, $p_{\mathrm{rep}} = .99$, but in this case the interaction was not, $F(1, 12) = 0.071$, $p_{\mathrm{rep}} = .57$. Thus, the effect of notation at long SOAs (52 ± 15 ms) was absorbed during the PRP slack time at short SOAs (see Fig. 2d), a result consistent with a manipulation that affects a perceptual stage of processing (Pashler, 1994; Sigman & Dehaene, 2005). However, the distance manipulation resulted in comparable increases in RT2 for short and long SOAs (see Fig. 2c), a result compatible with our conclusion that this manipulation affects processing

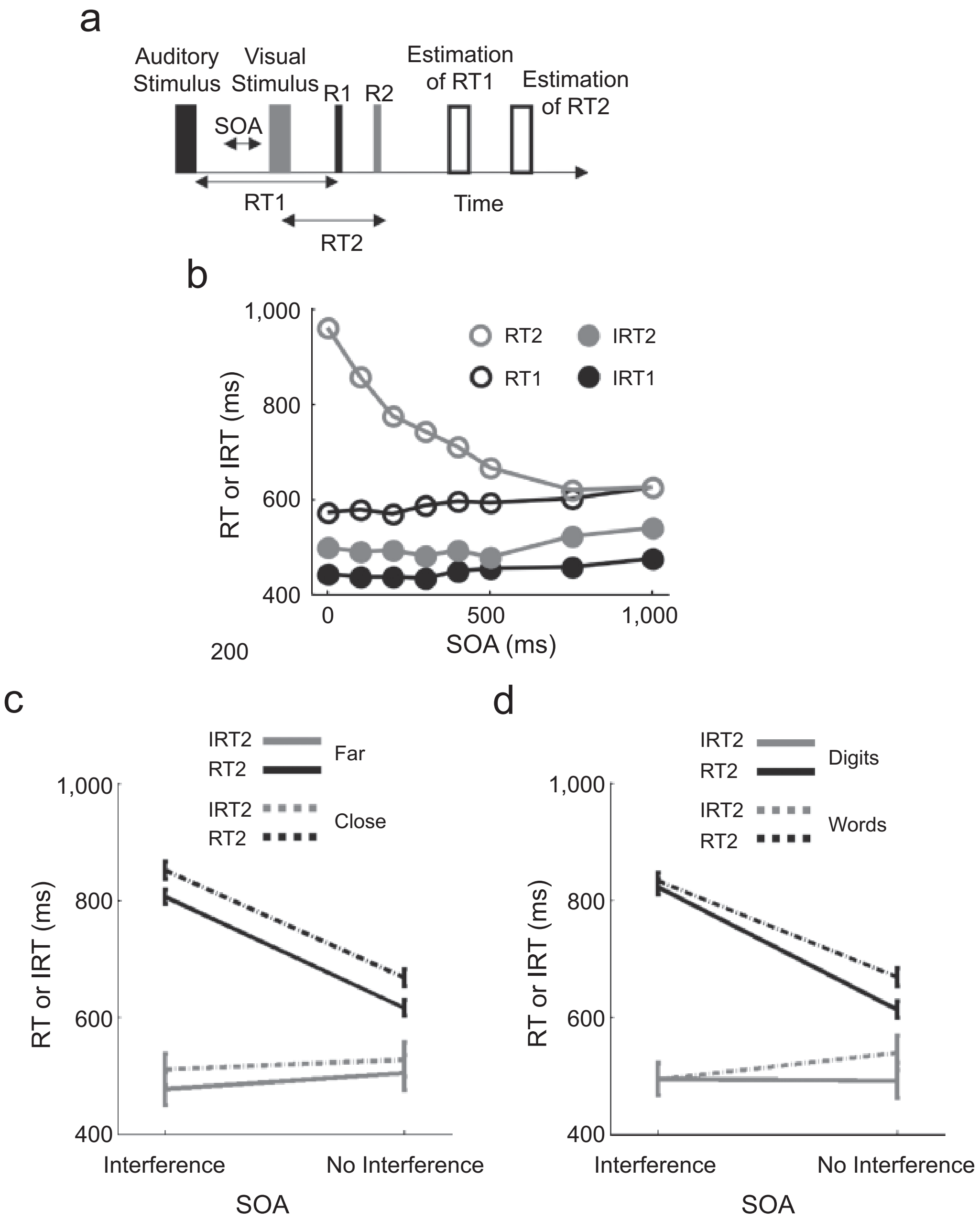

**Fig. 2.** Display sequence (a) and results (b, c, and d) for dual-task blocks in Experiment 2. In these blocks, subjects had to respond rapidly to a tone-discrimination task and a number-comparison task, presented at a variable stimulus onset asynchrony (SOA). They then estimated the time they thought it took them to perform each task (i.e., their introspective reaction time, or IRT), using a continuous graded scale. The graphs present (b) reaction times (RTs) and IRTs on the two tasks (i.e., RT1 and RT2, respectively, and IRT1 and IRT2, respectively) as a function of SOA, (c) RTs and IRTs on the number-comparison task as a function of SOA and distance of the target number from the reference, and (d) RTs and IRTs on the number-comparison task as a function of SOA and notation. For (c) and (d), SOAs were collapsed into two categories: interference (short SOAs, < 350 ms) and no interference (large SOAs, > 350 ms). Error bars indicate standard errors.

at a central level. In summary, the objective RTs complied perfectly with the classical pattern found in similar PRP studies (Sigman & Dehaene, 2005).

Strikingly, however, the IRTs exhibited a completely different pattern. Most notably, both IRT1 and IRT2 were totally unaffected by SOA (see Figs. 2b–2d). Thus, the main PRP effect, an increase of almost 200 ms in RT2 on the interference trials compared with the noninterference trials, was not noticed by introspection: Subjects' estimates of the time it took them to complete the second task were unaffected by SOA. We tested

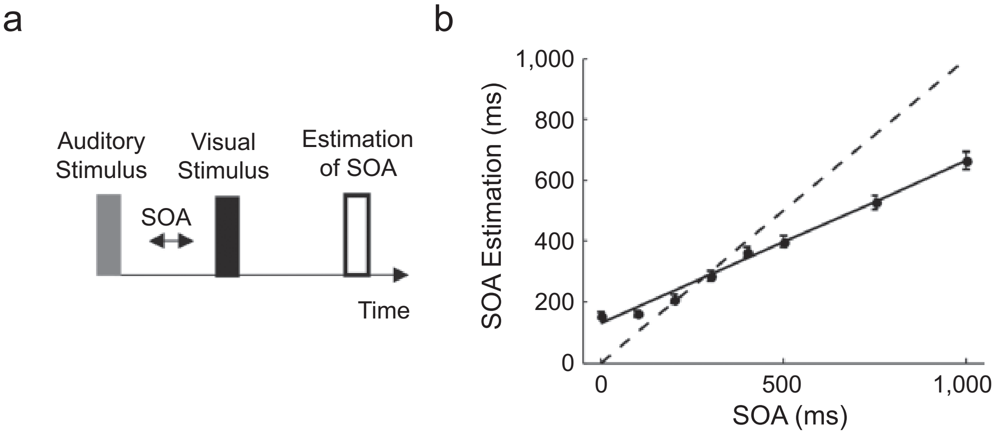

**Fig. 3.** Display sequence (a) and results (b) for control blocks in Experiment 2. In these blocks, subjects estimated the temporal interval between the two stimuli on each trial (SOA). The graph shows the relation between subjects' estimates of SOAs and objective SOAs; the regression line; and, for comparison, the identity line. Error bars indicate standard errors.

this absence of introspective access to the PRP delay with an ANOVA on mean IRT2, parallel to the analysis for RT2, and found that SOA (interference, no-interference) did not have a significant effect on IRT2 (interference: $M$ = 486 ms, $SD$ = 60 ms; no-interference: $M$ = 510 ms, $SD$ = 65 ms), $F(1, 12) = 1.60$, $p_{\text{rep}} = .8$.

Although there was no effect of SOA (interference) on IRT2, the interactions between SOA and distance and between SOA and notation showed the same pattern as for RT2 (see Figs. 2c and 2d): In the SOA × Notation ANOVA, although SOA had no significant effect, we found a marginally significant main effect of notation on IRT2 (Arabic digits: $M$ = 486 ms, $SD$ = 62 ms; spelled words: $M$ = 510 ms, $SD$ = 65 ms), $F(1, 12) = 4.4$, $p_{\text{rep}}$ = .91. In addition, the Notation × SOA interaction was significant, which indicates that notation had a different impact on IRT inside versus outside the interference period, $F(1, 12) = 10.8$, $p_{\text{rep}} = .97$. This interaction was in the same direction as found for the RTs (see Fig. 2d). In the comparable SOA × Distance ANOVA (Fig. 2c), we found a main effect of distance on IRT2 (far numbers: $M$ = 483 ms, $SD$ = 61 ms; close numbers: $M$ = 514 ms, $SD$ = 62 ms), $F(1, 12) = 8.0$, $p_{\text{rep}} = .96$. There was no main effect of SOA, $F(1, 12) = 1.13$, $p_{\text{rep}} = .76$, and no interaction between the two factors, $F(1, 12) = 2.2$, $p_{\text{rep}} = .84$. In brief, the IRT2 results demonstrate that participants were not aware of the PRP delay, but that outside the interference period (at longer SOAs), when the PRP effect was factored out, they were able to access some fine differences between conditions (notation and distance effects).

Can the absence of an SOA effect on IRT2 be explained by subjects' inability to perceive the temporal interval separating the two targets? In the control blocks, in which the stimuli were unchanged from the dual-task blocks and subjects simply concentrated on estimating the SOA, we found a good linear relation between the actual SOA and subjects' estimates (mean within-subjects $r^2 = .94$, $SD = .06$; see Fig. 3). The estimation of SOA was not significantly affected by the notation and distance factors. This control indicates that the participants' distorted estimation of RT2 in the dual-task blocks was not due to a basic inability to estimate the onset time of the target for the second task.

## DISCUSSION

The main findings of this study are twofold: First, they establish the validity of the IRT methodology. Second, they reveal a limit on temporal introspection.

On the methodological side, we have shown that participants are able to provide accurate introspective estimates of their RT. Of course, a limitation of this method is that the IRT measure does not directly probe the perception of an ongoing duration, but rather probes the memory of a past duration. Indeed, the fact that introspection is often a form of retrospection was noted by James (1890) and early writers on introspection, and clearly contributes to the fallibility of introspective measures (Armstrong, 1963). Despite this intrinsic difficulty, our results demonstrate the remarkable accuracy of introspective estimates of task duration: With minimal training, participants excelled at estimating the duration of their internal processes, and these estimates showed subtle effects of notation and distance.

In Experiment 1, participants' performance might perhaps be explained without any appeal to introspection. That is, they might have simply monitored the time elapsed between two external events, the onset of the visual stimulus and the tactile or auditory event accompanying their response. If this were the case, however, IRTs should always correlate with objective RTs. In Experiment 2, however, we found dissociations between objective RTs and IRTs. The results suggest that during the PRP interference period, subjects precisely time a hidden, internal event—the onset of central processing. This finding cannot be explained by participants' reliance on external events for their estimations, and it supports our view that participants' estimates were derived from genuine introspection.

This brings us to the second, and most important, outcome of our study: We have shown that not all cognitive events are available as internal markers for time estimation. The absence of the PRP effect in IRTs (Experiment 2) suggests that introspection about time spent on a task reflects mostly the duration of the central processing of that task. Specifically, in the PRP experiment, participants were not sensitive to the entire extent of the task: On interference trials, IRTs did not include the initial perceptual and waiting times for the second task, but apparently included only the duration of the central decision process.

The greater impact of central-stage processes on introspective estimates of duration is consistent with models of conscious experience that equate access to consciousness with a second, late stage of information processing (Chun & Potter, 1995; Norman & Shallice, 1986; Shallice & Burgess, 1996) during which information becomes globally available to many processors (Baars, 1988; Dehaene et al., 1998). Models of dual-task processing suggest that the selection of responses is the key process that ties up central resources during the PRP, and that the variable duration of this process is due to a slow, random-walk accumulation of evidence toward one or the other decision (Sigman & Dehaene, 2005, 2006). For the simple tasks considered here, such response selection is the only processing stage that is arbitrary and nonautomatized. The global-workspace model (Baars, 1988; Dehaene et al., 1998) predicts that because of this arbitrariness, this stage, which requires linking existing processors in novel ways according to arbitrary instructions, relies heavily on the global broadcasting and exchange of information within the global workspace. Hence, this model nicely accounts for the observed coincidence between the central stage, as defined by PRP analysis, and the introspectively accessible stage, as defined by our quantified-introspection method.

The absence of a PRP effect on introspective estimates suggests that experimental manipulations that reduce the availability of executive attention can lead subjects to report central processing time as their estimation of task duration. In Experiment 1, however, under conditions in which executive attention could be entirely focused on a single task, the notation factor—which we had previously shown to involve a parallel, perceptual stage of processing (Sigman & Dehaene, 2005)—had an effect on introspective estimates. This finding suggests that in the absence of dual-task interference, subjects *can* attend to the entire extent of a task, including the perceptual stage. It will be important for further research to examine the flexibility of introspection regarding time and to establish a taxonomy of which brain processes are accessible to introspection.

Our findings fit within a broader series of studies showing that different factors, such as attention, predictability, eye movements, and novelty, can generate distortions of subjective temporal intervals (Eagleman et al., 2005; Johnston, Arnold, & Nishida, 2006; Morrone, Ross, & Burr, 2005; Pariyadath & Eagleman, 2007; Tse, Intriligator, Rivest, & Cavanagh, 2004). It must be emphasized that in all these previous studies, subjects estimated the duration of an external event, whereas in our study, subjects introspected about their own processing time. Nevertheless, particularly relevant to the present study is the observed effect of attention on the perception of time. Tse et al. demonstrated that attentional orienting may be a cause of temporal distortions, showing that rare, "oddball" stimuli tend to last subjectively longer than frequently presented stimuli. To explain their results, they appealed to the notion that time estimation is not based on an absolute clock, but rather depends on the amount of change perceived (Brown, 1995; Fraisse, 1963; Kanai, Paffen, Hogendoorn, & Verstraten, 2006). This quantity, in turn, can be affected by attention and processing demands (Tse et al., 2004). This model may explain our observation of introspective blindness to the delays of the PRP. During completion of the first task, attention is diverted both from the exact onset time of the second task's target and from the perceptual processing of that target (as assumed by sequential models of the PRP and the attentional blink, or AB). To explain our results, one merely has to assume, as an extreme version of the hypothesis advanced by Tse et al., that inattention can lead to a total blindness to elapsed time.

In this respect, it is interesting to relate the present PRP paradigm to the AB. In a dual-task paradigm, when the second stimulus is interrupted by a mask, it often becomes inaccessible to conscious report, leading to an AB (Raymond, Shapiro, & Arnell, 1992). The PRP and AB are deeply related phenomena (Jolicoeur, 1999); it is possible to switch from one to the other by making minimal alterations of the experimental paradigm, and stochastic switches between the PRP and AB have been observed without changing the stimuli or tasks (Jolicoeur, 1999; Raymond et al., 1992; Wong, 2002). Our experiments suggest that during the PRP, processing time itself is blinked.

Using the method of quantified introspection, we have shown that the PRP delay is unnoticed in introspective experience. Going beyond this observation, we believe that quantified introspection may provide a new and important tool in the study of conscious and nonconscious cognitive processing more generally. The robustness of our results suggests that quantified introspection provides a powerful methodology for mapping the contents of conscious experience within current understanding of cognitive architecture. Further studies might usefully compare introspections of mental duration with introspections of other parameters amenable to introspection and quantification, such as the sense of effort and confidence.

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(RECEIVED 10/12/07; REVISION ACCEPTED 3/30/08)