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L C *, M , F A [1], [1], M

Department of Psychology and Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing 100871, China
Key Laboratory of Machine Perception (Ministry of Education), Peking University, Beijing 100871, China

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1. Introduction

D (D , T , & C , 2004; S , S , F , & E , 1990). M (S , 1990). (TOJ),

* : D P B K L B M H , P U , B 100871, C
E-mail address: CLH@ (L. C).
[1] T

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nization, and rhythm coordination (Jaskowski & Rusiak, 2005, 2008; Laasonen, Service, & Virsu, 2002; Virsu, Lahti-Nuuttila, & Laasonen, 2003).

In the last decade, studies of temporal processing in dyslexics have changed focus from the unisensory (visual) domain to a multisensory context, mostly by applying the temporal ventriloquism effect to the task of TOJ (Hairston, Burdette, Flowers, Wood, & Wallace, 2005; Harrar et al., 2014; Virsu et al., 2003). In temporal ventriloquism, temporal aspects of a visual stimulus such as its onset, interval, or duration, can be shifted by concurrent task-irrelevant but slightly asynchronous auditory stimuli (Bertelson, 1999; Burr, Banks, & Morrone, 2009; Chen & Vroomen, 2013; Fendrich & Corballis, 2001; Freeman & Driver, 2008; Morein-Zamir, Soto-Faraco, & Kingstone, 2003; Scheier, Nijhawan, & Shimojo, 1999; Shi, Chen, & Müller, 2010; Vroomen and de Gelder, 2004). For example, the perceived onset time of a visual stimulus can be biased by the presentation of a task-irrelevant and slightly asynchronous auditory stimulus (Fendrich & Corballis, 2001; Scheier et al., 1999). Hairston et al. (2005) investigated the role of the temporal ventriloquism effect in studying the effects of task-irrelevant auditory information on the performance of a visual TOJ task. They found that dyslexic subjects• performance differed significantly from that of control subjects. This difference occurred because dyslexics integrated auditory and visual information over longer time intervals (i.e., with expanded temporal windows), and showed low sensitivities for discriminating visual temporal order (Hairston et al., 2005). In a similar vein, Laasonen et al. (2002) examined temporal window of integration (TWIN) in dyslexic adults and age and IQ matched controls using audio-tactile temporal order judgements, and found a relative longer stimulus-onset asynchrony (SOA) for the dyslexic group, indicating the multisensory TWIN is generally larger than the one in unisensory conditions.

Stimuli presented in different sensory modalities can share a number of phenomenological attributes. The discrimination of (visual) temporal order, however, is modulated by the processing of concurrent task-irrelevant (and non-temporal) features of the stimuli presented (Droit-Volet & Gil, 2009; Eagleman, 2008; Kanai, Paffen, Hogendoorn, & Verstraten, 2006; Xuan, Zhang, He, & Chen, 2007). For example, people usually associate higher-pitched sounds with smaller/higher/brighter/sharper objects, and lower-pitched sounds with larger/lower/dimmer/rounder objects (Hubbard, 1996). These associations show the synesthetic correspondence between the physical features in different sensory events. Factors such as pitch/loudness in the auditory dimension with size/brightness in the visual dimension could modulate the strength of the crossmodal temporal capture effect including the temporal ventriloquism effect (Evans & Treisman, 2010; Gallace & Spence, 2006; Guzman-Martinez, Ortega, Grabowecky, Mossbridge, & Suzuki, 2012; Makovac & Gerbino, 2010; Parise & Spence, 2008; Parise & Spence, 2009; Parise & Spence, 2012; Spence, 2011; Sweeny, Guzman-Martinez, Ortega, Grabowecky, & Suzuki, 2012). By testing the normal developing adult subjects, Parise and Spence (2008) used the documented synesthetic association between auditory pitch and visual size to show that synesthetic congruency could modulate TOJ performance. They asked adult participants to execute a visual TOJ task in which two synchronous/consecutively presented visual "ashes (one small, one large) were "anked by two auditory beeps (one of low pitch, the other of high pitch), with 150 ms

Table 1
D [illegible] (TD) [illegible] (DD).

G [illegible]

, 伟 , / 2/, 伟大 - ; 田/ 2/, 种田 -) . P

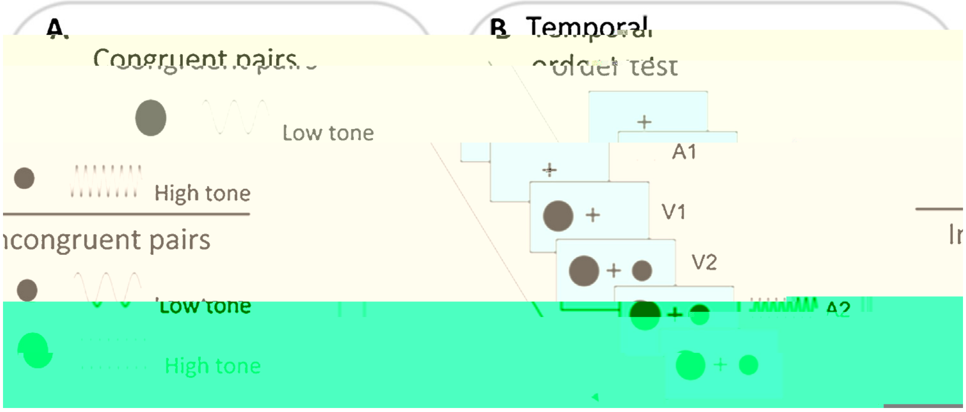

Fig. 1. S... E... 1. (A) L... (B) S... P... T... (V1 ... V2, ... 33, 66, 100, 166 ... 233 ...) ... (A1 ... A2). T... (SOA ...) ... A1 ... V1, ... A2 ... V2, ... 150 ...

2.4.2. Experiment 2: visual size-auditory pitch matching

A ... TOJ ... (E ... 1), ... [redacted] ... 2, [redacted] ... ISI ... disc ..., since ...

T [illegible] TOJ [illegible] : (1) D [illegible] JND [illegible] ; (2) D [illegible]

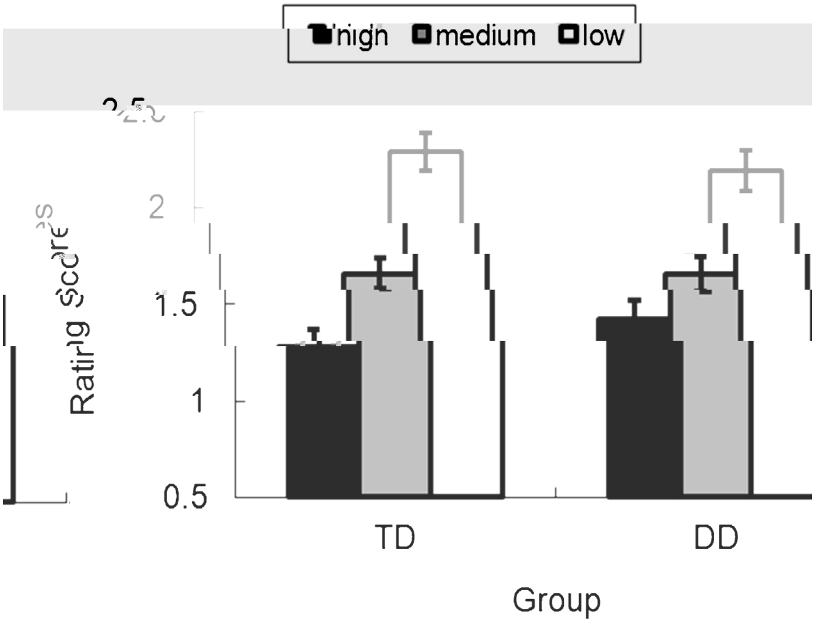

Fig. 5. A ... V... 1 ... V... 2 ... V... 3 ... T ... T ...

... T ... $F(2,40) = 0.563$, $p = 0.574$ $\eta_p^2 = 0.027$.

... (RT). G ... RT ... TD ... (1310 ± 66 ...) ... DD ... (1259 ± 66 ...), $F(1, 20) = 5.182$, $p < 0.05$. T ... RT ... 1062 ± 52 ... (...), 1310 ± 69 ... 1086 ± 67 ... (300 H...), ... (2300 H...), ... (4300 H...), $F(2,40) = 6.828$, $p < 0.01$, $\eta_p^2 = 0.255$. ... RT ... RT ... $p < 0.05$ ... < 0.05, $\eta_p^2 = 0.206$. I ... TD ... RT ... 953 ± 74 ... (...), 1213 ± 98 ... 973 ± 95 ... (300 H...), ... (2300 H...), ... (4300 H...). I ... DD ... RT ... 1171 ± 74 ..., 1408 ± 98 ... 1199 ± 95 ... T ... $F(2,40) = 0.023$, $p = 0.977$, $\eta_p^2 = 0.001$.

T ... DD ... TD ... (H... & R..., 2001; H... et al., 2014). ... (...).

4. General discussion

T ... (L..., S..., & V..., 2001; T..., M..., & F..., 1993), ... TOJ ... H ... DD ... JND ... TD ... (B...-S..., ... & V..., 2012; H... et al., 2005). O ... P... S... (2008). T ... TOJ ... JND ... (B... et al., 2009; S... et al., 2010). I ... (... JND ...). T ... (...) ...

[illegible]

[illegible] ([illegible]). T[illegible] [illegible] (F[illegible]., 2013; [illegible]., 2009).

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