TEMPORAL IMPAIRMENT IN DEAFNESS

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Abstract

In this study we compared the performance of deaf and control participants under three temporal tasks: time reproduction, time production and time discrimination tasks with the same short duration (500, 1000 and 1500 ms). Moreover, participants performed the reproduction and production tasks also with longer duration (3, 4 and 5 s). Testing time perception with different methodologies allows investigating the different cognitive functions that are involved in time perception. Furthermore, we employed millisecond and second range duration to investigate a possible relationship between time perception and language dysfunction that is often presented in deaf patients. Nine deaf adults (mean age 54.98 yrs) and 9 controls (mean age 54.38 yrs) participated in the study. Significant differences were found between groups with the discrimination, reproduction and production tasks when participants judged longer durations.

Researchers often use visual or auditory stimuli in their experimental settings on temporal judgment. According to modality-appropriateness hypothesis (Welch & Warren, 1980), perception gives the precedence to the "best" sensory modality for the task, vision for spatial judgment and auditory for temporal judgments (Wada, Kitagawa, & Noguchi, 2003). Some studies have shown that deaf patients have poor temporal perception, both in the millisecond and seconds range (Kanabus, Szelag, Kolodziejczyk, & Szuchnik, 2004; Kowalska & Szelag, 2006; Tirinelli, Brunettti, & Olivetti-Bernardini, 2009) confirming the modality-appropriates hypothesis. However, other studies have reported similar performances between deaf participants and controls (Poizner & Tallal, 1987; Nava, Bottari, Zampini, & Pavani, 2008) possibly due to brain reorganization that compensates the auditory deprivation in favor of visual specialization in deaf patients. Comparisons between studies are, however, limited because of methodological differences and the different durations employed.

In fact, within the prospective paradigm (when a person is aware during a time period that a duration needs to be estimated; Block, Zakay, & Hancock, 1998), different methodologies could be used and employment of one or the other may emphasized different temporal abilities. In the time production method, participants are required to produce a duration converting an objective duration into subjective defined time duration. In the time reproduction method, participants experience duration and are required to reproduce the previous perceived duration. This method does not require the knowledge of conventional duration units. In the time discrimination method, two duration intervals are presented and participants are required to discriminate the longer or briefer one (Block et al., 1998).

The aim of this study is to investigate temporal perception in deaf participants employing three different timing tasks (time reproduction, time production and time discrimination) that point out different temporal and cognitive abilities. Visual stimuli are employed in this study and participants are tested with short (500, 1000 and 1500 ms) and long (3, 4 and 5 s) durations.

Method

Nine deaf adults (F = 5; mean age = 54.98 yrs; DS = 7.32) and 9 control adults (F = 5; mean age = 54.38 SD = 5.12) took part in the study. Mean education for deaf adults was 10.22 yrs (SD = 3.03) and mean education for control adults was 9.63 (SD = 2.32). No significant

differences were found between groups for age [$t(15)= .16$, $p= .87$] and education [$t(15)= .45$, $p = .65$]. Demographic and clinical characteristics of deaf adults are reported in Table 1. None of the deaf participants used acoustic support. All participants were tested individually in a quiet room in their own home. Participants performed three temporal tasks (time reproduction, time production and time discrimination) and tasks to control cognitive (Raven Standard Progressive Matrices) and linguistic abilities (Token test). No difference was found between groups on Raven [$t(15)= .62$, $p= .87$] and Token test [all participants obtained the best score: *36*].

Table 1. Demographic and clinical description of deaf participants. Participants present different ethiologies but mainly due to meningitis.

Subject	Age	Sex	Education (years)	Duration of Deafness (years)	Ethiology
1	55	F	13	55	Meningitis
2	58	M	13	54	Meningitis
3	47	M	11	47	Congenital
4	44	F	8	44	Congenital
5	50	F	13	48	Otitis
6	61	F	8	58	Meningitis
7	54	F	13	50	Meningitis
8	57	M	8	56	Meningitis
9	68	M	5	66	Meningitis

Time reproduction task: Participants were instructed to reproduce the duration of the stimulus previously presented. At the center of the screen a black circle appeared for short (500, 1000 and 1500 ms) or long (3, 4 and 5 s) durations. When the stimulus disappeared, participants were instructed to keep press the space bar for the same duration that the stimulus was on screen. *Time production task*: Participants were instructed to produce short (500, 1000 and 1500 ms) or long (3, 4 and 5 s) durations. At the centre of the computer screen appeared a sentence indicating the duration to produce (e.g. "produce 5 seconds"). Participants were instructed to keep press the space-bar for the duration indicated. The same apparatus and stimuli used in the reproduction task were employed in the production task. *Time discrimination task*: Participants are instructed to judge two different durations. The first stimulus presented was the standard (500, 1000 and 1500 ms) followed by the comparison one. The comparison was 25% longer or shorter than the standard. Participants were instructed to press two distinct keys: one key if the second was longer than the first one and another key if the second was shorter than the first one. Training phase was included before each task, no feedback was provided.

Statistical analysis: Time reproduction and time production data were analyzed in term of absolute errors (i.e., the number of timing errors, in seconds, regardless of their direction). Separate ANOVAs were conducted on absolute errors for the short and long durations. The between-subject factor was group (deaf vs. control) and the within-subject factor was duration. Performance accuracy (percentage of correct responses) was analyzed in time discrimination task and included 2 groups (deaf vs. controls) x 3 durations (500, 1000 and 1500 ms).

Results

Time reproduction task

Short durations (500, 1000 and 1500 ms): No significant effect of duration [$F(1,32)= .233$, $p=.11$, $\eta^2_p= .127$] or group [$F(1,16)= 129.05$, $p= .73$, $\eta^2_p= .007$] was found. No significant interaction group × duration [$F(2,32)= .05$, $p= .94$, $\eta^2_p= .003$] was found. Deaf adults reproduced short stimulus durations as accurate as controls.

Long durations (3, 4 and 5 s): Significant effect of duration [$F(2,32)= 19.47$, $p<.001$] was found. The magnitude of errors increased with the duration to be reproduced, and significant differences were found between all durations (581, 734 and 1.053 ms, respectively). No significant effect of group [$F(1,16)= 3.44$, $p= .08$, $\eta^2_p= .117$] was found. Interestingly, the group × duration interaction was significant [$F(2,32)= 5.68$, $p<.01$] (see Figure 1). Significant difference was found between groups in the 5 sec duration: Control adults were less accurate than deaf adults. Significant differences were found within the control group between all duration, while deaf participants equally reproduced all durations.

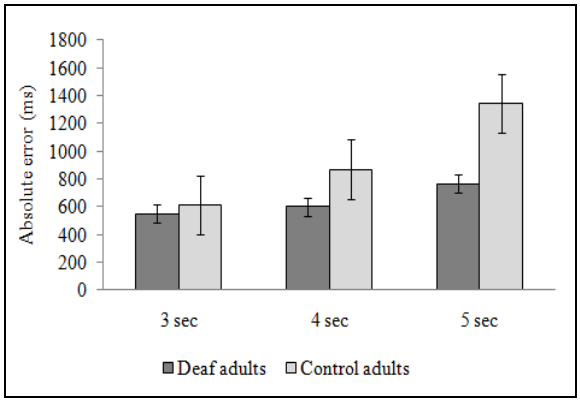

Figure 1. The mean absolute errors in the time reproductions task in deaf and control.

Time production task

Short durations (500, 1000 and 1500 ms): Significant effect of duration [$F(2,32)= 19.02$, $p<.001$] was found. The magnitude of errors increased with the duration to be produced, and significant differences were found between all durations (309, 505 and 673 ms, respectively). No significant effect of group [$F(1,16)= .90$, $p= .35$, $\eta^2_p= .053$], neither interaction group × duration [$F(2,32)= 1.64$, $p= .20$, $\eta^2_p= .093$] were found. Deaf adults produced short stimulus durations as accurate as controls.

Long durations (3, 4 and 5 s): Significant effect of duration [$F(2,32)= 41.83$, $p<.001$] was found. The magnitude of errors increased with the duration to be produced, and significant differences were found between all durations (257, 308 and 367 ms, respectively). No significant effect of group [$F(1,16)=4.09$, $p=.06$, $\eta^2_p= .204$] neither interaction group × duration [$F(2,32)=2.175$, $p=.13$, $\eta^2_p=.120$] was found. Deaf adults produced long stimulus durations as accurate as controls.

Time discrimination task

Significant effect of group was found [$F(1,16)= 17.13$, $p< .001$]. Deaf adults were more accurate than controls (83% vs. 69%). No significant effect of duration [$F(2,32)=1.37$, $p=.267$, $\eta^2_p=.079$] or interaction group × duration [$F(2,32)=.57$, $p=.56$, $\eta^2_p=.035$] were found.

Conclusion

Deaf adults performed as accurate as controls in the time reproduction and the time production when engaged with short durations (500, 1000 and 1500 ms), however when tested with the time discrimination task deaf adults performed better than controls. These results provide experimental evidence for the notion of task dependent sensitivity in time perception, and confirmed the superiority of the time discrimination task pointing out differences between groups when short durations are engaged (Rammsayer, 2001). The time discrimination task not only show temporal differences between groups but is also a suitable task to investigate attentional resources and processing speed. Compared to others tasks, the time discrimination task required participants to accurately perceive durations, quickly compare the relative duration to discriminate the longer or the briefer one. Better performance in the deaf group may be explained by higher attentional resources in deaf participants (Nava, et al., 2008). Deaf adults were more accurate than controls when tested with the time reproduction task with the longest duration (5 s). Better performance obtained by deaf participants could be explained by higher attentional and memory resources presented in deaf participants, while no differences were found between groups in the production task,which did not required additional cognitive functions but only the translation between objective to subjective time perception. In summary, deaf adults presented similar or better temporal abilities compared to controls, and this may be due to better attentional resources.

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