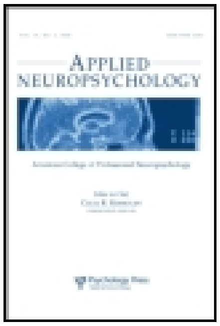

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Social Communication Impairs Working-Memory Performance

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Performance on working-memory tests is frequently used in experimental psychology and neuroscience, as well as in neuropsychological testing and clinical screening. It can be strongly affected by the social context and the communication style of the experimenter. We tested this hypothesis in two experiments, examining standardized neuropsychological working-memory tests in different social communication contexts. Our results show that the more ostensive communication context (eye contact, exaggerated intonation contours) impairs working-memory performance. These results draw attention to the fact that the communication style of the examiner could have a robust effect on working-memory performance and could even modify clinical diagnosis.

Keywords: *live speech and recorded voice, natural pedagogy, neuropsychological testing, ostensive communication, social influences, third-party observer, working memory*

Working-memory tests are frequently used in psychology and neuroscience research and as a diagnostic tool in clinical neuropsychology. They are most commonly applied in dyadic situations such as clinical screening and neuropsychological testing. The tester or experimenter gives instructions, reads aloud the items, or shows the task to the participants. Classical social psychology studies (Zajonc, 1965) and recent studies in neuropsychology (Gavett & McCaffrey, 2007; Yantz & McCaffrey, 2007) and social neuroscience (Frith & Frith, 2008) show that the social context has important effects on motor and cognitive tasks. Moreover, the theory of natural pedagogy, which is one of the most influential theories of the cognitive sciences in the past decade (Rahman, 2007), also addresses this question (Csibra & Gergely, 2009; Topál, Gergely, Erdohegyi, Csibra, & Miklósi, 2009) proposing that ostensive-communicative context (e.g., eye contact, exaggerated intonation contours) can help to acquire general knowledge; however, it can impair performance when information is not generalizable (e.g., episodic facts that can be obtained only in the "here-and-now"). Hence, performance in clinical and neuropsychological tests could also be strongly influenced by the social context

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especially based on the communication style of the tester or experimenter. Although it is an important methodological concern in the field of clinical neuropsychology and neuroscience, which could affect screening and testing protocols, it has not been empirically investigated. The aim of the present study was to fill this gap by exploring the role of communicational and contextual factors in dyadic working-memory testing situations.

EXPERIMENT 1

Methods

Participants. Twenty-four healthy, right-handed students from the University of Szeged participated in the experiment (12 males and 12 females; age, $M = 20.75$ years, $SD = 1.56$; years of education, $M = 14.29$, $SD = 1.46$). All participants provided signed informed consent agreements and received no financial compensation for their participation. Ethics approval was obtained by the Psychology Ethics Committee at the University of Szeged, Institute of Psychology.

Tasks and procedure. Working-memory performance was assessed by two widely used memory tasks, the Listening Span Test (Daneman & Blennerhassett, 1984; Janacsek, Tánczos, Mészáros, & Nemeth, 2009) and the Counting Span Test (Case, Kurland, & Goldberg, 1982; Kane et al., 2004). Participants performed all tasks twice (with different stimuli): Instructions to the participants were given once by live speech and once by recorded voice. The order of the conditions was counterbalanced. There was a male experimenter and a female experimenter in our study. To control for potential gender effects and for interactions between the gender of experimenters and subjects, half of the male participants and half of the female participants were assigned to the male experimenter, and the other half of each the male participants and female participants were assigned to the female experimenter. The experimenter remained in the room during the entire experiment, but when the participant listened to the recorded voice, the experimenter avoided any interactions with the participant.

The *Listening Span Test* (Daneman & Blennerhassett, 1984; Janacsek et al., 2009) is one of the most widely used working-memory tasks. In this task, the participants are required to listen to increasingly longer sentences and to recall the final word of all the sentences in each set, in the original order the sentences were heard. The number of presented sentences in a set ranged from two to eight. A participant's listening span capacity is a simple number representing the highest number of last words recalled in the correct order in a set of sentences (e.g., 6 represents six last words correctly recited in the correct order from a sequence six 6 sentences).

The *Counting Span Test* is also a working-memory task (Case et al., 1982; Kane et al., 2004) in which participants have to recall digits against a background counting task. In our study, each trial included three to nine blue circles as targets, one to nine blue squares, and one to five yellow circles as distractors on a grey background. Participants counted aloud the number of blue circles in each trial, and when finished with the count, they repeated the total number. When presented with a recall cue, participants recalled each total from the preceding set, in the order in which they appeared.

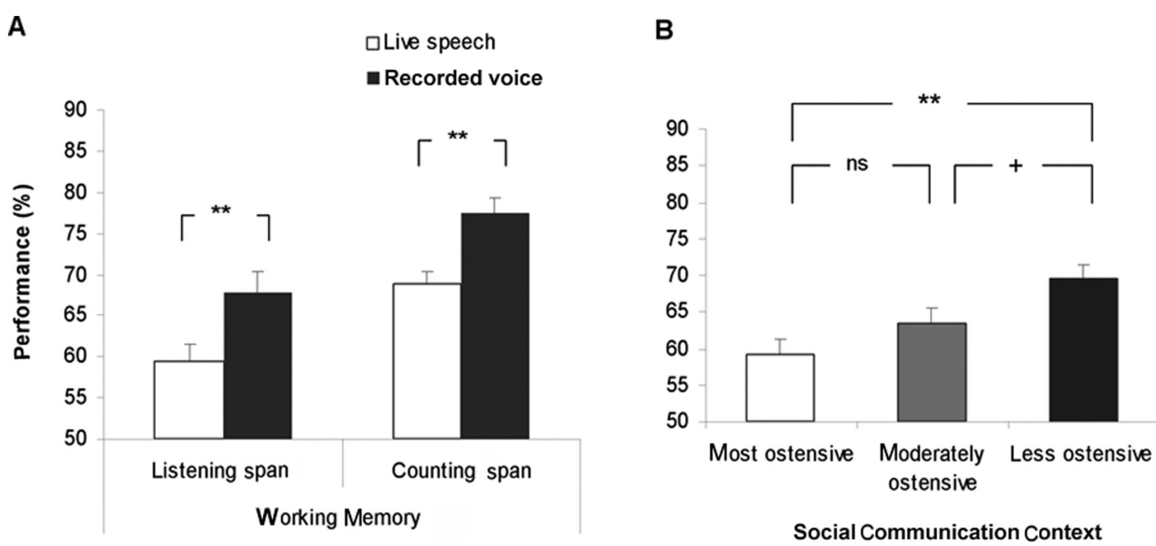

FIGURE 1 (A) Mean performance of the Listening Span and Counting Span tasks in the Live Speech and Recorded Voice conditions. (B) The mean performance on the Listening Span task in the three conditions. Error bars represent standard error means. $ns = p > .1$. $+p < .1$. $^{*}p < .05$. $^{**}p < .01$.

TABLE 1
Mean Performance (and Standard Deviations in Parentheses) for Live Speech and Recorded Voice Conditions in the Listening Span and Counting Span Tasks

	Live Speech	*Recorded Voice*
Listening Span Task	3.56 (0.82)	4.06 (0.90)
Counting Span Task	4.12 (0.96)	4.65 (0.90)

TABLE 2
Mean Performance and Standard Deviations (SD) for the Three Conditions

	Mean (SD)
The most ostensive-communicate	3.56 (0.94)
Moderately ostensive-communicative	3.81 (1.06)
The least ostensive-communicative	4.17 (1.01)

The number of presented trials in a set ranged from two to six. A participant's counting span capacity is calculated as the highest set size at which he or she was able to recall the totals in the correct serial order.

Results

A paired-samples *t*-test was used for comparison of the performance in the two conditions for each task separately. The performance was significantly higher in the Recorded Voice condition than in the Live Speech condition for both the Listening Span task, $t(23) = -2.89$, $p = .008$, $d = 0.59$, and Counting Span task, $t(23) = -2.75$, $p = .011$, $d = 0.56$. The performance increase was 8.33% for the Listening Span task and 8.68% for the Counting Span task (Figure 1A). The mean performance for the conditions separately is shown in Table 1.

EXPERIMENT 2

To address the issue of ostensive communication in more detail, we conducted a second experiment by using only live speech and manipulating both the instructions and the items in contrast to Experiment 1 in which only the instructions were manipulated.

Methods

Participants. Thirty-six healthy, right-handed students from the University of Szeged participated in the experiment (36 females; age, $M = 20.25$ years, $SD = 1.70$; years of education, $M = 13.14$, $SD = 1.46$). All subjects provided signed informed consent agreements and received no financial compensation for their participation. Ethics approval was obtained by the Psychology Ethics Committee at the University of Szeged, Institute of Psychology.

Task and procedure. In Experiment 2, working-memory capacity was measured by the Listening Span Test. We presented the stimulus of the task in three different communication styles: (1) with eye contact and exaggerated intonation contours, sitting opposite the participant (most ostensive-communicative), (2) without eye contact, monotonic prosody, sitting opposite the participant with a slightly twisted torso (approximately 30°; moderately ostensive-communicative), and (3) without eye contact, monotonic prosody, sitting behind the participant to exclude any body language (less ostensive-communicative). In the latter condition, participants were informed about the position change in advance to avoid the sudden increase of arousal. Different stimulus sets of the Listening Span task were used in the three conditions. Both the stimulus set and the order of the conditions were counterbalanced across participants. Similarly to Experiment 1, there was a male experimenter and a female experimenter in our second study. To control for the potential gender effects and interactions between the gender of experimenters and subjects, half of the participants were assigned to the male experimenter and the other half to the female experimenter.

Results

In the repeated-measures analysis of variance, the main effect of condition (most ostensive, moderately ostensive, and less ostensive) was significant, $F(2, 70) = 4.65$, $p = .013$. The LSD post-hoc analysis revealed a significantly higher performance in the less ostensive condition compared with the most ostensive condition ($p = .003$, $d = 0.54$); participants showed a 10.18% performance increase in the less ostensive condition. There was also a trend for the less ostensive condition and the moderately ostensive condition ($p = .079$, $d = 0.3$), with 6.02% higher performance on the former. There was no significant difference between the most ostensive and moderately ostensive conditions ($p = .255$, $d = 0.19$). The mean performance for the conditions separately is shown in Table 2. To sum up, in Experiment 2, we found that participants' working-memory performance was the highest in the least ostensive-communicative condition and was the worst in the most ostensive-communicative condition (Figure 1B).

DISCUSSION

Here we showed that communication context affects working-memory capacity: The examiner's ostensive-communicative style (live speech, eye contact, exaggerated intonation contours) impaired working-memory performance in both experiments.

Our results are consistent with the theory of natural pedagogy (Csibra & Gergely, 2009), suggesting that if a task requires more cognitive resources and immediate "here-and-now" episodic information processing (e.g., working-memory tasks), then ostensive communication impairs memory performance whereas nonostensive context facilitates it.

Complementing the natural pedagogy theory, attention can also play a crucial role in a dyadic testing situation. As humans are socialized and brought up in a social environment, attention is forcefully led by social cues (Frith & Frith, 2008). Performing worse in more ostensive conditions can be explained by limited capacity of attention in that cognitive resources need to be shared between processing of working-memory tasks and the social context of the situations. Previous eye-contact studies also support this suggestion because both children and adults generally avoid making eye contact with the examiner during short-term memory tasks (Goldfarb, Plante, Brentar, & DliGregorio, 1995; Plante, Plante, Rahm, Brentar, & Couchman, 1997).

To sum up, communication style has an effect on working-memory performance. Our results draw attention to the limitations of the methods used in clinical practice and empirical studies: Because the participants' performance depends on the communicational context, it is therefore more difficult to compare results in studies on brain–behavior interaction and to determine, for example, if a participant's performance is in the healthy range on a particular diagnostic tool. Our results suggest that to further control the effects of social context, the instruction and item presentation in working-memory tasks could be more effective with recorded voice compared with live speech. Further research is needed to explore how other aspects of human cognition and related brain systems are affected by the social communication context.

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