Sensory and motor encoding strategies in N-back tasks: Implications for working memory deficits in schizophrenia

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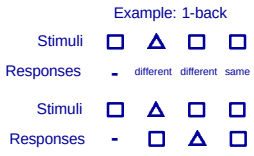
Introduction

N-back tasks are well established to measure working memory (WM) dysfunction in schizophrenia.

Two types of N-back task can be differentiated:

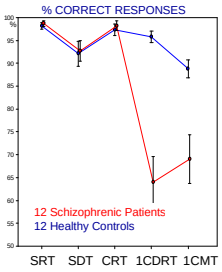
- **CMT: Continous matching tasks**
  Subjects have to match the features of the present stimulus with those of the stimulus presented N-back.
- **CDRT: Continous delayed response tasks**
  Subjects have to select the response depending on the information of the stimulus presented N-back.

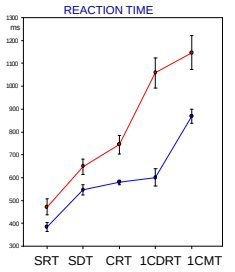


First-episode, neuroleptically naive schizophrenic patients solve both types of N-back tasks in a comparable time with comparable accuracy.

But compared to healthy controls the deficits in CMT tasks can be attributed to a slowing of basal cognitive processes already involved in choice reaction tasks (CRT). In contrast, the impairments seen in CDRT are more pronounced and can not be put down to deficits observable in the CRT control task.

This can be explained by the task solving behaviour of the healthy control subjects: They solve CDRT tasks in considerably less time and with higher accuracy than CMT tasks.





(Krieger et al. AJP 2005)

Do healthy controls apply different encoding strategies of the task relevant information depending on the type of N-back task ?

CMT The matching of stimulus features requires the maintenance of sensory stimulus information in WM -> retrospective sensory code

CDRT The response is selected based upon the information of a single stimulus before the delay -> prospective motor code ?

Method

Sample
32 healthy subjects (16 males, 16 females), 25.0 ± 3.4 years

Stimuli and Response
In each task 48 stimuli (50% squares, 50% triangles) were presented (duration 50ms).

Subjects had to move the cursor as fast as possible from a starting area to a target array.

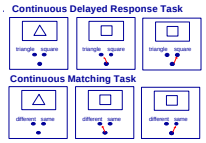
Dependent variables
% Correct Responses
Reaction Time (RT, Stimulus-Onset to reaching the target array)

Tasks

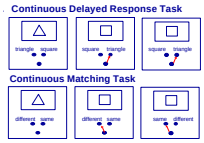
SRT: Simple Reaction	"React to all stimuli"
SDT: Stimulus Discrimination	"React to triangles only"
CRT: Choice Reaction	"React to triangles with triangle and with square to squares"
N-back-CDRT (N=1+ 2):	"React to the stimulus N-back"
N-back CMT (N=1 + 2):	"Compare the present stimulus with that N-back"

Predictability of the correct response side
Prerequisite for the use of a motor encoding strategy is that a task allows the response selection to occur before the delay.
A random arrangement of the target buttons was used to prevent that information in CDRT-tasks is hold online in a motor code.

100% predictability
Fixed arrangement of target buttons



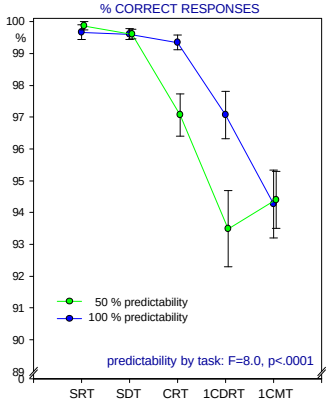
50% predictability
Random arrangement of target buttons

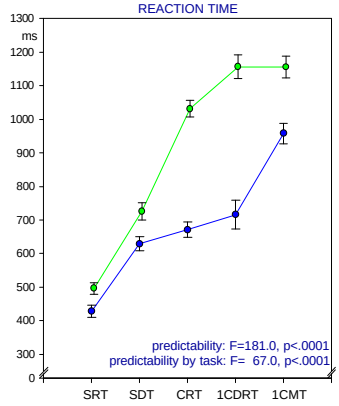


Design and Statistics
2x5-ANOVA with 2 repeated measurement factors
"predictability of the correct response side" (100% vs. 50%)
"task" (SRT, SDT, CRT, 1-CDRT, 1-CMT)

2x2x2-ANOVA with 3 repeated measurement factors
"predictability of the correct response side" (100% vs. 50%)
"N-back task" (CDRT, CMT) and "working memory load" (N=1, N=2)

Results



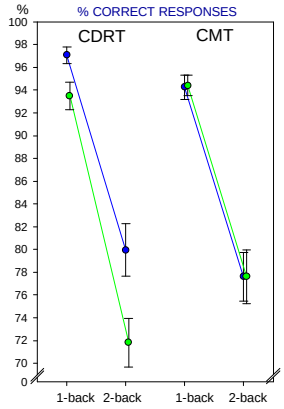


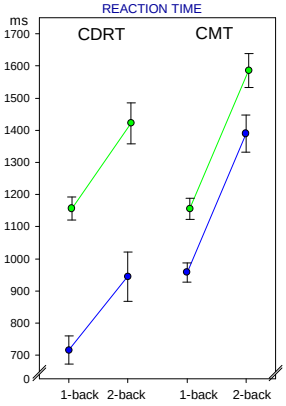
Accuracy decreased with 50% predictability
- in CRT and CDRT
- but not in SRT, SDT and CMT

⇨ CDRT and CMT were solved with equal accuracy.

RT increased with 50% predictability
- in all tasks,
- but most pronounced in CDRT

⇨ CDRT and CMT were solved in a comparable time.





Accuracy decreased with WM load
- in both types of N-back task
- in both types of target button arrangement

RT increased with WM load
- in both types of N-back task, but more pronounced in CMT
- in both types of target button arrangement

Discussion

Our data support the assumption that healthy subjects apply different encoding strategies depending on the type of N-back task:
CMT ⇨ sensory encoding strategy
CDRT ⇨ motor encoding strategy

When healthy subjects are forced to apply a sensory encoding strategy, the behaviour equals in CMT and CDRT, as it can be observed in schizophrenic patients.

The consideration of action related processes in WM might contribute to understanding the - sometimes diverging - results of WM studies in schizophrenia.

This might be important not only regarding behavioural data but also for the interpretation of hypo- and hyperactivation in prefrontal brain area.
Recent studies suggest that e.g. the activation of dorsolateral prefrontal structures is more pronounced when information is maintained in WM in a sensory code compared to the use of a motor representation (Curtis & D'Esposito, Neuroimage 2005).