Preliminary Results, Mario's Master Thesis, 25.09.2025

# Design

We observed percent correct responses (corrected by percent incorrect responses) in a repeated measurement design, which included the independent variables Target Position (TP, 1 vs. 2), Queried Item Position (QIP, 1 vs. 2), Target-to-Nontarget Similarity (TNS, low vs. high) and the Accessory Stimulus Position (ASP, 1 vs. 2), in a sample of N=30 [momentan noch: 26] participants.

# Results

As in Experiment 1, Target Position (TP) and Queried Item Position (QIP) interact significantly, F(1,200) = 45.46, MSE = 2.474, p < .001: if the queried item position matches the position of the target item, that is, the item that is refreshed or updated by the probe (in terms of Hz), performance is relatively increased than if they do not match (see Table 1 for the corresponding aggregated means and SDs in Experiment 1 vs. 2; see Tables 4.1 and 4.2 for a summary of the ANOVA results from Experiment 2 and 1, respectively).

Also in accordance with Experiment 1, Experiment 2 shows that this interaction between TP and QIP is significantly more pronounced when Target-to-Nontarget Similarity (TNS) is high rather than low, F(1,200) = 14.5, MSE = 0.791, p<.001 (see Table 2 for means and SDs of this three-way interaction). This means that when the difficulty of the task increases (i.e., TNS=high), a mismatch between the position of the target and the queried item (i.e., TP=1 and QIP=2 or vice versa) will impair task performance much more (compared to conditions where TP and QIP match) than when there is a relative decrease in task difficulty (i.e., TNS=low).

Once more, TNS is found to be a strong factor, F(1,25) = 47.4, MSE = 2.711, p<.001, which makes performance relatively increase when it is low (M=0.79, SD=0.27) and relatively decrease when it is high (M=0.62, SD=0.38).

**Table 1. Means (and SDs) for (error-corrected) percent correct, *p*(*c*), as a function of Target Position (TP) and Queried Item Position (QIP) from Experiment 1 (sample size *N* = 34) and Experiment 2 (*N* = 26)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Experiment 1 | | Experiment 2 | |
|  | *QIP* | | *QIP* | |
| *TP* | 1 | 2 | 1 | 2 |
| 1 | .48 (.26) | .29 (.41) | .73 (.29) | .60 (.43) |
| 2 | .19 (.36) | .50 (.32) | .65 (.36) | .83 (.19) |

*Note*. *p*(*c*) = *p*(*correct*) – *p*(*error*), where minuend and subtrahend represent the portion of correct and incorrect responses per condition.

**Table 2. Means (and SDs) for p(c) as a function of Target Position (TP), Target-to-Nontarget Similarity (TNS) and Queried Item Position (QIP) in Experiment 1 (without Accessory Stimulus) and Experiment 2 (with Accessory Stimulus)**

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment 1 |  |  | |
|  |  | QIP | |
|  | TP | 1 | 2 |
| TNS=low | 1 | .54 (.26) | .48 (.32) |
|  | 2 | .39 (.30) | .51 (.34) |
|  |  |  |  |
| TNS=high | 1 | .42 (.25) | .10 (.39) |
|  | 2 | .00 (.30) | .48 (.31) |
| Experiment 2 |  |  |  |
|  |  | 1 | 2 |
| TNS=low | 1 | .78 (.26) | .74 (.34) |
|  | 2 | .76 (.28) | .85 (.16) |
|  |  |  |  |
| TNS=high | 1 | .68 (.30) | .46 (.46) |
|  | 2 | .55 (.40) | .81 (.21) |

*Note*. *p*(*c*) = *p*(*correct*) – *p*(*error*), where minuend and subtrahend represent the portion of correct and incorrect responses per condition.

Differences between the two experiments show up with respect to Target Position (TP). First, TP's main effect was not significant in Experiment 1, but reaches statistical tendency in Experiment 2, F(1,25)=3.96, MSE=.613, p<.10: performance tends to be better, if the representation of the second list item (M=.74, SD=.30) rather than the first one (M=.67, SD=.37) is reinforced by the probe. Second, only in Experiment 2 does the factor TP interact with TNS, F(1,25)=4.67, MSE=.111, p<.05, in the sense that the effect of TP is greater when TNS is high (MTP=2=.68, SD=.35; MTP=1=.57, SD=.40) than when it is low. (MTP=2=.81, SD=.23; MTP=1=.76, SD=.30). Third, it interacts significantly with Accessory Stimulus Position (ASP), which was not included in the design of Experiment 1, F(1,200)=4.67, MSE=.111, p<.05: when the target is accompanied by the accessory stimulus, that is, if TP and ASP match, performance is lower than when they do not match (see Table 3). This interaction implies an interference effect of the auditory accessory stimulus on the encoding of the vibrotactile list item.

**Table 3. Means (and SDs) for p(c) when cross-tabulating Target Position (TP) and Accessory Stimulus Position (ASP) (based on Experiment 2 data)**

|  |  |  |
| --- | --- | --- |
|  | ASP | |
| TP | 1 | 2 |
| 1 | .65 (.37) | .68 (.37) |
| 2 | .76 (.28) | .72 (.32) |

*Note*. *p*(*c*) = *p*(*correct*) – *p*(*error*), where minuend and subtrahend represent the portion of correct and incorrect responses per condition.

**Table 4.1. Experiment 2 repeated-measures ANOVA of (error-corrected) percent correct on Target Position (TP), Target-to-Nontarget Similarity (TNS) and Queried Item Position (QIP) on**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Parameters* | | | |
| *Model* | *df* | *F* | *MSE* | *p* |
| *TP* | 1,25 | v | .613 | .058~ |
| *ASP* | 1,25 | 0.01 | .000 | .919 |
| *TNS* | 1,25 | 47.4 | 2.711 | .000\*\*\* |
| *QIP* | 1,200 | 1.217 | .066 | .271 |
| *TP × ASP* | 1,25 | 4.665 | .111 | .041\* |
| *ASP × QIP* | 1,200 | 0.002 | .000 | .967 |
| *QIP × TNS* | 1,200 | 0.001 | .000 | .977 |
| *TP × TNS* | 1,25 | 4.665 | .111 | .041\* |
| *TP × QIP* | 1,200 | 45.46 | 2.474 | .000\*\*\* |
| *ASP × TNS* | 1,25 | 1.212 | .047 | .281 |
| *TP × ASP × TNS* | 1,25 | 0.433 | .012 | .516 |
| *TP × ASP × QIP* | 1,200 | 0.047 | .003 | .829 |
| *TP × TNS × QIP* | 1,200 | 14.531 | .791 | .000\*\*\* |
| *ASP × TNS × QIP* | 1,200 | .025 | .001 | .875 |
| *TP × ASP × TNS × QIP* | 1,200 | 0.018 | .001 | .893 |

*Note*. *TP* = *Target Position*, *ASP* = *Accessory Stimulus Position*, *TNS = Target-to-Nontarget Similarity*, *QIP = Queried Item Position*; *MSE* = *Mean Sum of Squared Errors; p = Level of significance.*

*R* comment for running regression model*: p*\_*c* ~ *TP*\**ASP*\**TNS*\**QIP* + *Error*(*participant* / (*TP*\**ASP*\**TNS*\**QIP*))

**Table 4.2. Experiment 1 repeated-measures ANOVA of (error-corrected) percent correct on Target Position (TP), Target-to-Nontarget Similarity (TNS) and Queried Item Position (QIP) on**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Parameters* | | | |
| *Model* | *df* | *F* | *MSE* | *p* |
| *TP* | 1,33 | 0.651 | 0.107 | .426 |
| *TNS* | 1,33 | 78.89 | 3.546 | .000\*\*\* |
| *QIP* | 1,132 | 2.672 | 0.219 | .104 |
| *QIP × TNS* | 1,132 | 0.481 | .039 | .489 |
| *TP × TNS* | 1,33 | 1.622 | .034 | .212 |
| *TP × QIP* | 1,132 | 49.296 | 4.044 | .000\*\*\* |
| TP × TNS × QIP | 1,132 | 20.078 | 1.647 | .000\*\*\* |

# Model-based analyses drawing on the Vibrotactile Model of Resonance (VMR)

Ein Bild, das Text, Reihe, Diagramm, Steigung enthält.

KI-generierte Inhalte können fehlerhaft sein.

**Figure 1. Observed and predicted (error-corrected) percent correct yes/no judgments under each experimental condition**

*Note*. Goodness-of-fit measures: BIC = -60.8; 𝜒2= 5.68, df = 16 – 7 = 9, 𝜒2crit = 16.9, *p* = .771; Error bars represent the observed Standard Errors of the Means; abbreviations at the abscissa: S = Same condition (Probe equals Target), first digit (after "S\_") = Target Position, second digit = ASP, third digit = QIP

**Table 9. List of free parameters (Vibrotactile Model of Resonance): Abbreviation, meaning, best-fitting estimate**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Meaning** | **Best-fitting estimate** |
| βAS | Rate of temporal context drift evoked by Accessory Stimulus | .83 |
| βL | Integration rate for list item context (target and nontarget) | .85 |
| βProbe,low | Integration rate for Probe context when TNS is low | .56 |
| βProbe,high | Integration rate for Probe context when TNS is high | .94 |
| βret | Integration rate for temporal context retrieved in response to the question prompt | .99 |
| wFC | Weight for newly learned bindings from Layer F to C | .01 |
| wCF | Weight for newly learned bindings from Layer C to F | .69 |

# Appendix

**Table A1. *p*(c) under all *TP* (*Target Position*) × *ASP* (*Accessory Stimulus Position*) × *QIP* (*Queried Item Position*) × *TNS* (*Target-to-Nontarget Similarity*) conditions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***TP*** | **ASP** | **QIP** | **TNS** | ***Mean p(c)*** | ***SD p(c)*** |
| 1 | 1 | 1 | high | .65 | .30 |
| 2 | 1 | 1 | high | .57 | .36 |
| 1 | 2 | 1 | high | .69 | .30 |
| 2 | 2 | 1 | high | .49 | .44 |
| 1 | 1 | 2 | high | .44 | .46 |
| 2 | 1 | 2 | high | .84 | .19 |
| 1 | 2 | 2 | high | .45 | .48 |
| 2 | 2 | 2 | high | .77 | .24 |
| 1 | 1 | 1 | low | .76 | .29 |
| 2 | 1 | 1 | low | .76 | .30 |
| 1 | 2 | 1 | low | .80 | .24 |
| 2 | 2 | 1 | low | .75 | .26 |
| 1 | 1 | 2 | low | .71 | .36 |
| 2 | 1 | 2 | low | .85 | .16 |
| 1 | 2 | 2 | low | .76 | .33 |
| 2 | 2 | 2 | low | .85 | .16 |

*Note*. *p*(*c*) = *p*(*correct*) – *p*(*error*), where minuend and subtrahend represent the portion of correct and incorrect responses per condition.

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**Table 3. Means (and SDs) of (error-corrected) percent correct, p(c), as a function of Target Position**

|  |  |
| --- | --- |
| *Target Position* | |
| 1 | 2 |
| .67 (.37) | .74 (.30) |

*Note*. *p*(*c*) = *p*(*correct*)-*p*(*error*)

**Table 4. Means (and SDs) of p(c) as a function of TNS**

|  |  |
| --- | --- |
| *TNS* | |
| low | high |
| .79 (.27) | .62 (.38) |

**Table 5. Means (and *SD*s) for p(c) when cross-tabulating *Target Position* and *ASP***

|  |  |  |
| --- | --- | --- |
|  | *ASP* | |
| *Target Position* | 1 | 2 |
| 1 | .65 (.37) | .68 (.37) |
| 2 | .76 (.28) | .72 (.32) |

**Table 6. Means (and *SD*s) for p(c) when cross-tabulating *Target Position* and *TNS***

|  |  |  |
| --- | --- | --- |
|  | *TNS* | |
| *Target Position* | low | high |
| 1 | .76 (.30) | .57 (.40) |
| 2 | .81 (.23) | .68 (.35) |

**Table 7. Means (and *SD*s) for p(c) when cross-tabulating *Target Position* and *QIP***

|  |  |  |
| --- | --- | --- |
|  | *QIP* | |
| *Target Position* | 1 | 2 |
| 1 | .73 (.29) | .60 (.43) |
| 2 | .65 (.36) | .83 (.19) |

**Table 8. Means (and *SD*s) for p(c) as a function of *Target Position (TP)*, *TNS* and *QIP***

|  |  |  |  |
| --- | --- | --- | --- |
| *Means* (and *SD*s) |  |  |  |
|  |  | QIP | |
|  | TP | 1 | 2 |
| TNS=low | 1 | .78 (.26) | .74 (.34) |
|  | 2 | .76 (.28) | .85 (.16) |
|  |  |  |  |
| TNS=high | 1 | .68 (.30) | .46 (.46) |
|  | 2 | .55 (.40) | .81 (.21) |

**Table 1. *p*(c) under all *TP* (*Target Position*) × *ASP* (*Accessory Stimulus Position*) × *QIP* (*Queried Item Position*) × *TNS* (*Target-to-Nontarget Similarity*) experimental conditions / combinations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***TP*** | **QIP** | **TNS** | ***Mean p(c)*** | ***SD p(c)*** |
| 1 | 1 | low | .54 | .25 |
| 2 | 1 | low | .39 | .30 |
| 1 | 2 | low | .48 | .32 |
| 2 | 2 | low | .51 | .34 |
| 1 | 1 | high | .42 | .26 |
| 2 | 1 | high | .00 | .30 |
| 1 | 2 | high | .10 | .33 |
| 2 | 2 | high | .48 | .34 |

**Table 2. Results of the repeated-measures ANOVA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *Parameters* | | | |
| *Model* | *df* | *F* | *MSE* | *p* |
| *TP* | 1,33 | 0.651 | 0.107 | .426 |
| *TNS* | 1,33 | 78.89 | 3.546 | .000\*\*\* |
| *QIP* | 1,132 | 2.672 | 0.219 | .104 |
| *QIP × TNS* | 1,132 | 0.481 | .039 | .489 |
| *TP × TNS* | 1,33 | 1.622 | .034 | .212 |
| *TP × QIP* | 1,132 | 49.296 | 4.044 | .000\*\*\* |
| TP × TNS × QIP | 1,132 | 20.078 | 1.647 | .000\*\*\* |