Effects of verb directedness and individual differences on the processing of reflexives

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The effect of structural constraints (e.g. Binding Theory, BT) on reflexive processing is not fully understood. Some argue that referents not licensed by BT interfere with reflexive processing: [1] found that presence of a gender-matching competitor (John in ex.(1)) causes reading slowdowns, compared to sentences with no gender-matched competitor (Jane). However, others disagree (e.g. [7,8,3]). We ran an internet-based mouse-tracking study to (i) assess prior claims that verb directedness and individual differences modulate competition during real-time processing and to (ii) explore the feasibility of using mouse-tracking for large-scale, internet-based studies.

Prior work: [5] ran a small, in-lab mouse-tracking study on English to test if ***verb directedness*** modulates the extent to which BT-inaccessible competitors interfere with reflexive processing, and if this depends on ***individual differences in processing style***. 18 L1 English undergrads heard sentences like (2), manipulating **(i)** whether the embedded verb was self-directed (e.g., *shave, wash*), other-directed (e.g., *kick, tickle),* or nonsense (e.g. *drib*, no semantics), and **(ii)** whether the matrix subject (not licensed by BT) matched reflexives' gender.

People saw words in L/R corners (matrix & embedded subjects, L/R-balanced, Fig.1), clicked 'start' to hear the sentence, and clicked on the last-mentioned entity (in targets => whoever 'himself/herself' refers to). Mouse trajectories were recorded. Afterwards, they filled in questionnaires, e.g. Autism Spectrum Quotient (AQ [2]). Based on prior work (not on reflexives, see [9,6]), [5] predicted ***high AQ scorers*** might focus on syntactic requirements (bottom-up syntactic cues), while ***lower AQ scorers*** might focus more on verb directedness (top-down knowledge). (So-called 'autism spectrum traits' are present in the general population, at lower levels, e.g. [2,9]. [5] followed [9] in using AQ to tap into *variations in cognitive processing style*.)

[5] found, with all verb types, more deflection of the mouse trajectory towards gender-matching than gender-mismatching matrix subjects, suggesting ***non-local DPs can interfere with reflexive processing***, even if unavailable according to BT. [5] also found ***individual differences*** on verb directedness: people with lower AQ scores (median split: lower half) were less sensitive to structural constraints and more sensitive to verb directedness than higher AQ scorers (top half).

Current study: As the number of participants in [5]'s study was small (n=18), the reliability of their findings is unclear. We tested (i) if their findings replicate in a larger and more diverse sample and (ii) the feasibility of mouse-tracking for large-scale data collection on the internet. We used the same design, method, stimuli and task as [5], ex.(2) (24 targets, 40 fillers), but implemented a web-based version of mouse-tracking with PCIbex. Participation was remote (n=121 native English speakers, Prolific). We measure the deflection towards the non-local (matrix) subject as the Area Under the Curve (AUC) ([4], Fig.2, analyzed with Mousetrap [10] in R).

Results. Fig.3 shows people's final clicks, and reveals a strong preference for the local subject (in line with BT). In addition, there are significantly less local subject choices (i.e., more *non-local subject* choices) when the non-local subject matches the reflexive's gender ($p=0.019$). This suggests that ***non-local DPs interfere with reflexive processing****, even if inaccessible according to BT*. **Fig.4** shows AUC trajectory data for all participants. Numerically, echoing what Fig.3 shows, there is more competition from matrix subjects whose gender matches the reflexive (dark blue>light blue), but this is not significant. We also find no clear effects of verb directedness.

However, Figs.5-6 (AUC data) reveal **a processing style difference** between lower and higher AQ scorers (median split, like [5]): (i) low AQ scorers show competition from gender-matching matrix subjects only with other-directed verbs, not self-directed or nonce verbs (Fig.6) ($p<.05$), while high AQ scorers show no significant effects (Fig.5). Thus, with low AQ scores, **verb directedness modulates the presence of competition**, as we predicted, in line with [5].

Our findings suggest that verb directedness and individual differences modulate competition during reflexive processing, and that internet mouse-tracking is promising, but faces some challenges due to variability in hardware, which requires more data and careful data cleaning.

(1) **[John/Jane]** thought that **Bill** owed **himself** another….
(2) Example (3x2 design): **{Mary/Peter}** said that John **{tickled/shaved/dribbed}** himself.

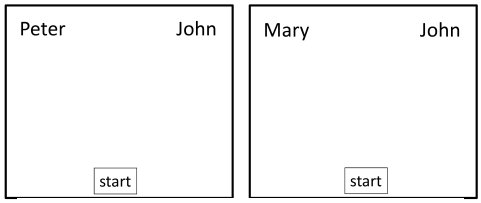

Fig.1. Example displays (gender-matching condition and gender-unmatching condition)

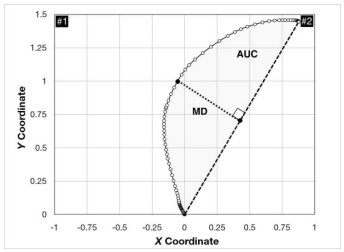

Fig.2. Schematic of Area Under the Curve (AUC), the amount of deflection towards the competitor from a straight line (Freeman's Mousetracker Manual)

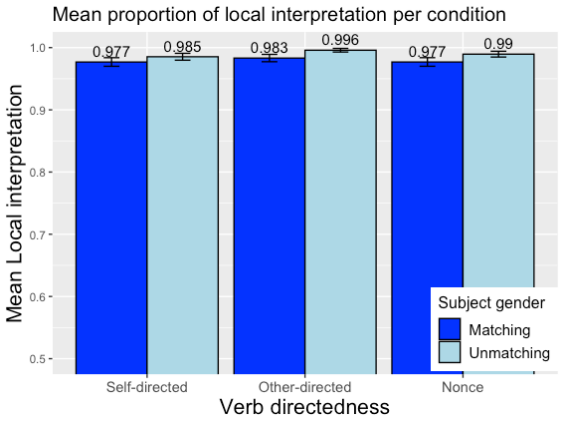

Fig.3. Final choices (clicks), all participants

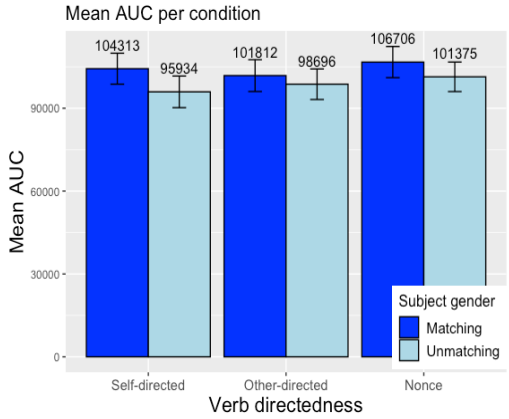

Fig.4. Area under the curve (AUC), all participants

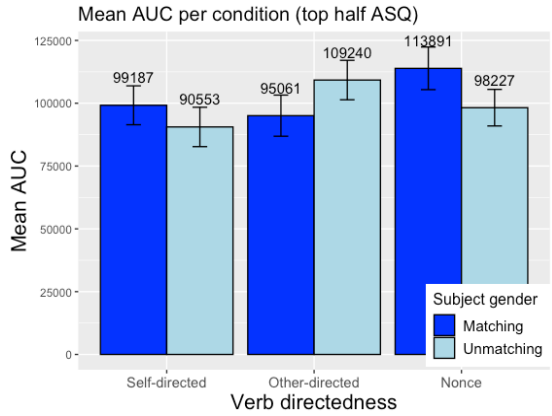

Fig.5. Deflection towards (competition from) matrix subject (AUC); high AQ scorers (n=64)

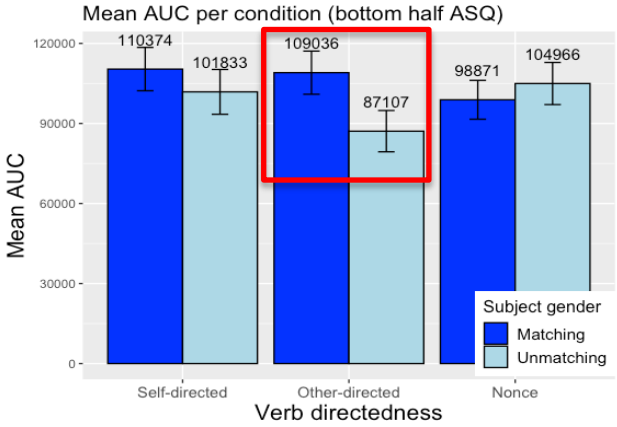

Fig.6. Deflection towards (competition from) matrix subject (AUC); low AQ scorers (n=57)

[1] Badecker/Straub 2002. The Processing Role of Structural Constraints on the Interpretation [2] Baron-Cohen etal. 2001.The Autism-Spectrum Quotient [3]Dillon etal. 2013. Contrasting intrusion profiles for agreement and anaphora. [4]Freeman/Ambady 2010. MouseTracker [5]Kaiser/Harper 2013. Individual differences in anaphoric processing. [6] Ota/Stewart 2008. Lexical effects on speech perception in individuals with ‘‘autistic’’ traits. [7]Sturt 2003. Time-Course of the Application of Binding Constraints in Reference Resolution. [8]Xiang et al. 2009. Illusory licensing effects across dependency types [9]Yu 2010. Perceptual Compensation Is Correlated with Individuals’ ‘‘Autistic’’ Traits. [10]Wulff etal. 2021. Movement tracking of cognitive processes.