How common ground information affects reference resolution in children and adults: evidence from behavioral and neurophysiological measure

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Ambiguous referring expressions can be resolved by taking the speaker's perspective. This requires considering common ground (CG) information, that is, mentally or perceptually shared information of both interlocutors. Yet competing accounts about the use of CG information during reference resolution exist. In the Constraint-based Account, listeners can make rapid use of CG during their online utterance interpretation (e.g., Hanna et al., 2003; Nadig & Sedivy, 2002). The Egocentrism Account assumes that CG information is integrated only late with effort, after an initial egocentric interpretation has led to errors (e.g., Apperly et al., 2010; Keysar et al., 2000). The Autonomous Activation Account suggests that listeners actively attempt to take a speaker's perspective in anticipation of a linguistic expression, but then fail to fully integrate CG information due to autonomous activation of privileged information (Barr, 2008; Epley et al., 2004). While these accounts are predominantly based on eye-tracking findings, we use event-related potentials (ERPs), a method with a very high temporal resolution, to further examine WHEN CG information affects reference resolution during utterance comprehension in adults. In addition, we consider the question of WHEN from a developmental perspective: we examine 4- and 5-year-old children with the visual-world eye-tracking paradigm to specify the developmental trajectory of adult-like sensitivity to CG information in online processing.

Both children and adults played versions of the referential communication game (e.g., Keysar et al. 2000). The crucial feature of this game is to manipulate the conditions of visual access between interlocutors by occluding certain objects in a grid: some objects are in CG, to some objects only the participant has privileged access to.

34 adults played a computerized version of the referential communication game. They saw a 4x4 grid containing two sets of three different sized objects (i.e., small, medium, big) and two single distractors on a screen. A virtual confederate behind the grid provided auditory instructions (e.g., "Move the big star to the top."). Participants then had to drag and drop the corresponding object in a field above the grid with a computer mouse.

In *conflict* trials, the object that fit the confederate's request best from the perspective of the participant ("competitor"; e.g., the big star) was occluded from the confederate's view. Thus, participants had to consider CG information to select the correct object ("target"; e.g., the medium-sized star). The experiment also entailed a *no-conflict* condition (targets visible for confederate and participant), a *no-hidden* condition (no occlusions at all), and filler trials. In advance of the experimental phase participants were instructed to mind the confederate's perspective and underwent a practice phase with corrective feedback (2-step instruction similar to Wang, 2015). During the test phase, ERPs were recorded with a 32 active electrode system (BrainProducts, Gilching). Reaction times (RTs) and accuracy rates were measured.

The accuracy results revealed that participants mastered integration of CG in the conflict condition (accuracy rate 100%). However, perspective taking has its costs: RTs showed that participants were on average 195ms (SD ±7.2ms) slower in the *conflict* condition compared to the *no-conflict* and *no-hidden* conditions. In the ERPs, increased processing costs in the *conflict* vs. *no-conflict* and *conflict* vs. *no-hidden* conditions were reflected by enhanced late positivities in posterior (600-1200ms) and anterior (800-1400ms) regions, relative to the onset of the noun (e.g., “star”). The different peak latencies and the distinct topography point to different underlying functional mechanisms that might involve the calculation of the self- vs. other-perspective and the resolution of conflict, according to McCleery et al. (2011). In sum, this experiment shows that CG information is integrated with effort, right after the presentation of the critical noun during utterance comprehension (i.e., relatively late). It also points to a number of processes involved in perspective taking that need to be further examined.

In the ongoing study with the 4- and 5-year-old German-speaking children we utilized a real 3x3 grid. An experimenter served as real confederate, although pre-recorded speech was used. Each child was presented with 4 different set-ups, containing one main trial. The experimental trials followed training in which the child also saw the grid from the confederate’s side and received corrective feedback. Children’s eye-gazes were tracked while solving the task using a remote eye-tracker and eye-tracking glasses (SMI RED-m, ETG, Teltow). In addition measures of Theory of Mind (the Smarties task, Perner et al., 1987; the Sally-Anne task, Baron-Cohen et al., 1985), working memory (digit span, from German K-ABC, Melchers & Preuß, 1994) and inhibitory control (Flanker Task, Kopp et al., 1994) were obtained from each child.

Our preliminary analyses of the behavioral data (15 4-year-olds, 15 5-year-olds) indicate that children of both age groups mostly selected the object in privileged ground. Thus, they ignored the speaker’s perspective in their referential choice despite the corrective feedback they got during training. However, 5-year-olds tend to choose the non-privileged object more often (40.0%) than 4-year-olds (20.0%), but this difference did not reach statistical significance. Performance on all cognitive and social cognitive measures show tendencies for a positive correlation with children’s performance in the referential communication game. Ongoing testing of further children has to show whether these correlations will reach statistical significance. In addition, we will follow up with analyses of the eye-gaze data from this experiment to gain insight into the effect of common ground manipulation on online processing.

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