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Factors that affect action possibility judgments: The assumed abilities of other people

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ABSTRACT

Judging what actions are possible and impossible to complete is a skill that is critical for planning and executing movements in both individual and joint actions contexts. The present experiments explored the ability to adapt action possibility judgments to the assumed characteristics of another person. Participants watched alternating pictures of a person's hand moving at different speeds between targets of different indexes of difficulty (according to Fitts' Law) and judged whether or not it was possible for individuals with different characteristics to maintain movement accuracy at the presented speed. Across four studies, the person in the pictures and the background information about the person were manipulated to determine how and under what conditions participants adapted their judgments. Results revealed that participants adjusted their possibility judgments to the assumed motor capabilities of the individual they were judging. However, these adjustments only occurred when participants were instructed to take the other person into consideration suggesting that the adaption process is a voluntary process. Further, it was observed that the slopes of the regression equations relating movement time and index of difficulty did not differ across conditions. All differences between conditions were in the y-intercept of the regression lines. This pattern of findings suggests that participants formed the action possibility judgments by first simulating their own performance, and then adjusted the "possibility" threshold by adding or subtracting a correction factor to determine what is and is not possible for the other person to perform.

1. Introduction

The ability to judge and anticipate what actions are or are not possible to complete is an important early step in planning movements both in individual and social contexts. For example, one needs to be able to judge whether or not it is possible to safely pick up and manipulate a heavy water pitcher before grasping it. Likewise, one needs to be able to accurately judge whether or not someone with different motor capabilities, such as a young child, would be able to handle the water pitcher before passing it to that person. Although it is clear from our own personal experience that we are able to make adaptations to our judgments to account for the capabilities of other people, the strategies and processes that underlie these adaptations have yet to be clearly elucidated. The formation of such action possibility judgments is a multifaceted process that likely engages a number of systems and has been shown to be influenced by *sensorimotor* factors such as recent task experience, perspective, and current action potential (Chandresekharan, Binsted, Ayres, Higgins, & Welsh, 2012; Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008; Ramenzoni, Riley, Shockley, & Davis, 2008a, 2008b). The purpose of the present studies was to shed new light on the *cognitive* processes underlying action possibility judgments by investigating when and how individuals adapt their judgments for other people to the assumed motor capabilities of the other person.

Based on the results of previous experiments on action possibility judgments, it has been suggested that the core process underlying these judgments is a simulation of the to-be-judged action (Chandresekharan et al., 2012; Eskenazi, Rotshtein, Grosjean, & Knoblich, 2012; Grosjean, Shiffrar, & Knoblich, 2007). The current formulation of this simulation account is rooted in ideomotor (common coding) theory (Prinz, 1992, 2005; see also Decety, 2002; Hommel, Müsseler, Aschersleben, & Prinz, 2001). According to ideomotor theory, the neural codes that represent action generation are bound to the perceptual representations of the consequences that the actions have on the environment. Of particular relevance to the present paper, a suggested consequence of this perception/action coding system is that an individual can activate the common codes and run them offline to simulate motor performance and predict the subsequent action consequences. The most common use of such an offline simulation is thought to be during response selection because the simulation allows the actor to anticipate the consequences of a given action and, subsequently, determine if the correct action has been selected to achieve the goal. In the present paper, we focus on a

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related set of processes potentially using action simulation: the set of processes that leads to determining whether or not an action that is currently being observed is possible to perform or not.

Clearly, there are actions that can be judged as impossible to perform without the engagement of a simulation process. For example, with a basic knowledge of physics (gravity, resistance due to air or another medium, etc.) and mechanics of the human body (muscle forces, joint range of motions, etc.), one should be able to determine that it is impossible to run on water. For actions that are consistent with the laws of physics and mechanics, a further set of processes must be engaged. It has been suggested that these action possibility judgments are formed through a process in which the characteristics of the observed action are compared to an offline simulation of that action. When the characteristics of the observed action surpass a threshold of difficulty, they are judged to be impossible. On the other hand, observed actions that are equal to or below this threshold are judged to be possible (Chandresekharan et al., 2012).

As already discussed, it has been proposed that the core process of these judgments involves the offline activation of ideomotor codes and therefore involves activation of both perceptual and motor systems (e.g., Chandresekharan et al., 2012; Grosjean et al., 2007). The potential role of ideomotor coding, and related motor system activation, has been based on the results of a series of studies that makes use of the known relationship between movement time, endpoint accuracy, and movement difficulty that is captured by Fitts' equation (Fitts, 1954). In short, there is a distinct speed-accuracy trade-off in which actors must increase movement time (MT) to maintain accuracy and terminate the movement on the target location as the difficulty of the movement increases. In the case of reciprocal aiming movements, movement difficulty is a function of movement amplitude and target width — the smaller the target and/or the longer the movement, the more difficult the movement.

The recent studies on action possibility judgments exploit this known relationship by determining if action possibility judgments of a reciprocal aiming task are consistent with the speed-accuracy captured by Fitts' equation (Grosjean et al., 2007). In these studies, people watch a series of aiming movements between a pair of targets and then judge whether or not it is possible to maintain accuracy at the observed speed. On a given trial, participants are presented with a pair of pictures of a person with the index finger of the right hand on one of two targets (see Fig. 1). The finger of the person is on the right target in one picture and on the left target in the other picture. The picture with the finger on the right target is alternated with the picture with the finger on the left target at a specific time interval (stimulus onset asynchrony or SOA) throughout a trial to create the apparent motion associated with a person moving the finger between the targets at a set MT. The task of the participant is to judge whether or not it is possible to move between the targets at the shown speed and maintain accuracy (i.e., a judgment of the limits of the speed/accuracy trade-off in goal-directed aiming movements). The width of the target and the distance between the targets are consistent for the pair of pictures within a trial, but are systematically varied across the pairs of pictures on different trials such that there are specific combinations of target width and movement amplitude in accordance with the index of difficulty (ID) as computed by Fitts' Law (Fitts, 1954). Finally, the SOA between pictures was also varied across the trials such that there were different apparent MTs for each trial.

The key pattern of results from these studies is that the minimum MTs judged as possible closely follow Fitts' equation — the lowest MTs (i.e., the fastest movement speed) that participants judged as being "possible to move at while maintaining accuracy" increased linearly with the ID (Grosjean et al., 2007). Support for the role of an ideomotor-based simulation during this task has come from three main sources. First, in an fMRI study, Eskenazi et al. (2012) found that motor system activity increased as the ID of the to-be-judged movement increased. Second, Chandresekharan et al. (2012) showed that providing people with experience of the to-be-judged task can modify the judgments of what is possible or not to perform — presumably task experience modified

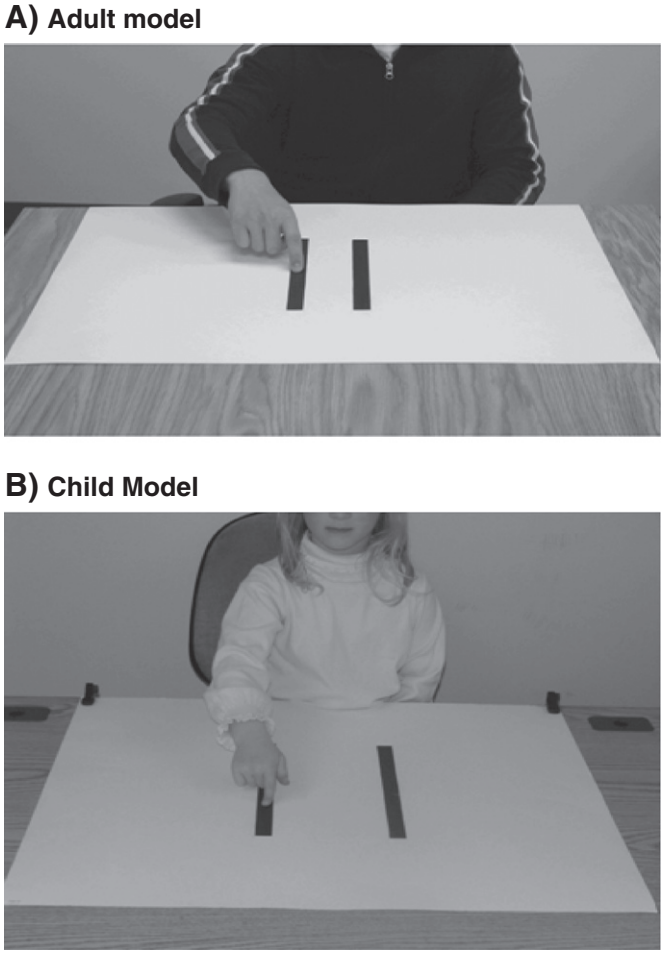

Fig. 1. Examples of the pictures used to generate the apparent motion stimuli. The Adult model (A) was used in Experiments 1–3 and the Child model (B) was used in Experiments 1 and 2.

judgments due to a refining of the linked perception/action codes. Third, Eskenazi, Grosjean, Humphreys, and Knoblich (2009) reported that the action possibility judgments of a person with a frontal brain lesion, though different from those of neurologically-intact peers, were consistent with the actual task performance (i.e., target width did not affect judged or actual MTs). Thus, the current literature supports the hypothesized role of ideomotor codes in the formation of these action possibility judgments and suggests that the person's own capabilities are at the core of the simulation and, hence, the action possibility judgment process.

There is a clear advantage to having ones' own motor capabilities as the core (or default mode) of the judgment process because people will most often make judgments about their own actions. There are, however, potential disadvantages to having ones' own motor capabilities as the core of the judgment process. This potential disadvantage is particularly poignant when considering the processes involved in trying to judge whether or not it is possible for someone else to complete a task because there are individual differences in motor capabilities. If an ego-centered judgment process is the core process, and this process is too rigid or inflexible, then the judgments for other people may be inaccurate because different people have different capabilities. Such an egocentric form of judgment might explain why we make mistakes when we estimate the action possibilities of others because the simulation is rooted in what *we* can do and the judgment process has not been accurately modified to account for the other person's capabilities. Evidence for such egocentric errors was reported by Cordovil and Barreiros (2010) who observed that adults tend to overestimate the maximum reachability of children because they may not account for age-related differences in