Personality and Individual Differences 52 (2012) 903–907

Contents lists available at SciVerse ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

The correlation of inductive reasoning with multi-dimensional perception

Michael Schwenzer *, Klaus Mathiak

RWTH Aachen University, Department of Psychiatry, Psychotherapy and Psychosomatic Medicine, Pauwelsstr. 30, 52074 Aachen, Germany

ARTICLE INFO

Article history:
Received 4 September 2011
Received in revised form 19 January 2012
Accepted 25 January 2012
Available online 23 February 2012

Keywords:
Inductive reasoning
Intelligence
Multiple categorizations
Auditory localization
Color perception

ABSTRACT

Intelligence correlated with perception in previous studies. The aim of this investigation was to specify the relationship between inductive reasoning and perception. For this purpose, 125 healthy adults performed the Raven's Advanced Progressive Matrices as measure of inductive reasoning and six perception tasks. Inductive reasoning correlated with simultaneous perception of locus and pitch ($r = .29$, $p < .001$) and with perception of four distinct colors ($r = .32$, $p < .001$). Inductive reasoning was not significantly associated with pitch discrimination, pitch contour perception after partialing out effects of covariates, pitch identification, and visual localization. Inductive reasoning, locus-pitch perception, and color perception required the processing of unrelated categories. Therefore, inductive reasoning and the correlating perception skills may share multi-dimensional mental representation. This multi-dimensional representation may differ from one-dimensional scales such as pitch. The findings suggest a differentiation of pre-semantic cognitions and its interactions with perception.

1. Introduction

Intelligence is well known to correlate with perception skills (e.g. Deary, 1994). The aim of the present study was to specify the relationship between a component of intelligence – inductive reasoning – and perception. Correlations of intelligence with specific not with all perception skills and same demands of the correlating tasks may help to unravel a common process.

Intelligence was associated with many perception skills in previous studies. In the auditory domain, pitch discrimination (Acton & Schroeder, 2001; Deary, 1994; Deary, Head, & Egan, 1989b; Helmbold, Troche, & Rammsayer, 2006; McCrory & Cooper, 2005; Olsson, Björkman, Haag, & Juslin, 1998; Raz, Willerman, & Yama, 1987), tone localization (Bates, 2005; McCrory & Cooper, 2005; Parker, Crawford, & Stephen, 1999), and the perception of complex tonal arrangements (Lynn & Gault, 1986; Lynn, Wilson, & Gault, 1989) correlated with intelligence. We suggest that the latter task is comparable with pitch contour perception (Dowling, 1978) because this task required processing series of tones. In the visual domain, intelligence correlated with color perception (Acton & Schroeder, 2001; Deary, Bell, Bell, Campbell, & Fazal, 2004) and localization (Deary, Caryl, Egan, & Wight, 1989a).

Most of the cited investigations disregarded that intelligence may correlate differentially with several perceptions skills. Indeed, perception skills were distinguishable, e.g. pitch discrimination, auditory localization, pitch contour perception, and pitch identification (Deutsch & Roll, 1976; Dowling, 1978; Schwenzer & Mathiak, 2007). Some of these perception skills may not interact with intelligence: One study failed to confirm a correlation between Raven's Progressive Matrices scores and pitch discrimination (Deary et al., 1989b). Pring, Woolf, and Tadic (2008) suggested that identifying absolute pitch was independent of intelligence. Thus, we hypothesized that the correlations between intelligence and perception skills are task-specific.

The present study assessed one component of intelligence to emphasize the differentiation of perception skills. In agreement with developmental psychologists (Hayes & Thompson, 2007) we focused on inductive reasoning as intelligence measure. Inductive reasoning is the recognition of regularity in a series of stimuli (Heit, 2000) and may evolve from the perception of feature similarity in pre-school age (Gentner & Medina, 1998; Hayes & Thompson, 2007). In higher age, cognitive concepts such as causality override perceptual comparisons (Hayes & Thompson, 2007; Rehder, 2006). However, inductive reasoning may interact with perception even in adults when the task requires the processing of stimuli without meaningful concepts. To test this hypothesis, we assessed inductive reasoning using the meaningless geometrical figures of the Raven's Progressive Matrices (Carpenter, Just, & Shell, 1990; Raven, 2001). The perceptual assessment comprised the skills discussed in the survey above. The emphasis on auditory rather than visual tests should enhance the sensitivity to detect supra-modal correlations between visually assessed intelligence and auditory perception.

Covariates such as sex and age could bias the correlation of intelligence with perception (Acton & Schroeder, 2001). Moreover, students of natural sciences scored higher in the Raven's Progressive Matrices (Heller, Kratzmeier, & Lengfelder, 1998). Musical

* Corresponding author. Tel.: +49 241 80 89 730; fax: +49 241 80 82 401.
E-mail address: mschwenzer@ukaachen.de (M. Schwenzer).

0191-8869/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.paid.2012.01.027

experience improved pitch discrimination (Micheyl, Delhommeau, Perrot, & Oxenham, 2006) and may correlate with intelligence (Schellenberg, 2004, 2006). However, there is a lack of studies linking performing arts with inductive reasoning. Thus, we monitored the potential influence of covariates, i.e. sex, age, education, musical and arts experience. The present study tested the hypothesis that inductive reasoning correlates with some but not with all perception skills. Previous findings suggested that performance in the Raven's Progressive Matrices might be associated particularly with auditory localization (Bates, 2005), pitch contour perception (Lynn et al., 1989), and visual localization (Deary et al., 1989a). We expected that the correlations of inductive reasoning with perception skills persist even after partialing out effects of covariates such as sex and thus could help to confirm a common cognitive process.

2. Material and methods

2.1. Participants

The study included 125 adults, 74 men and 51 women, between 18 and 36 years old ($M = 24.3$ years, $SD = 3.6$). We asked for participation on notices in student hostels and university buildings. Therefore, most volunteers were advanced students or graduates ($N = 114$), few participants served an apprenticeship ($N = 11$). The Edinburgh Inventory (Oldfield, 1971) ensured that only right-handed persons participated to reduce perceptual and sensomotor variance that could be associated with handedness (Ocklenburg, Hirnstein, Hausmann, & Lewald, 2010). Perception of tones with 440, 2000, or 4096 Hz frequencies at 20 dB SPL in the left or right ear in random order tested normal hearing. All participants stated correctly on which side the tones occurred. Naming correctly the colors of three rows, each of 24 colored bars, excluded color blindness (Bäumler, 1985). All subjects were naïve to the intelligence and perception tests.

2.2. Intelligence measure

The Raven's Advanced Progressive Matrices (Raven, 1995) was appropriate to assess inductive reasoning in this highly educated sample. Two sets were applied: Set I familiarized the participants with the task and was not scored. After that, the participants completed Set II displaying 36 items of increasing difficulty as a timed test (40 min). Each item comprised eight complex geometric figures and an empty figure arranged as a 3×3 matrix. The participants were asked to find the missing figure from a set of eight alternative figures. For correct performance, the participants had to detect multiple regularities in the figures, e.g. the sequences of geometrical figures (circle, square, rhomb) and the number of one through three lines crossing the figures.

2.3. Perception tests

We applied auditory tests which are appropriate to differentiate pitch perception skills and has been already published (Schwenzer & Mathiak, 2007): *Pitch Discrimination, Locus-Pitch Perception* (previously labeled *Localization*; however the task requires discriminating both left vs. right ear and pitch), *Pitch Contour Perception*, and *Pitch Identification*. Very briefly, to assess different auditory skills the tests varied pitches during the application of one tone vs. a series of tones with duration of 100 ms of each tone as well as whether same vs. different pitches occurred in the right and left ear. Apart from pitch identification, the participants had to respond to 60 tonal series with a pitch increase but not to 60 tonal series without pitch increase. During pitch identification, the participants should recognize four distinct pitches in 60 trials. The pitch differences were small in all tests to create difficult tasks.

We complemented the test battery with a *color perception* and a *visual localization* task in which 60 stimuli appeared within a horizontal bar of 2 cm height and 28 cm width at the top of the screen of a 17″ CRT monitor. The participant sat centered to the screen in a distance of 60 cm with a visual angle of 50°. The *color perception* task showed a red, yellow, green, or blue bar on a grey background with comparable brightness. Only one of four pixels displayed a color to increase task difficulty. The participants responded on the keypad whenever they perceived a color (left key = red, second from the left = yellow, third from the left = green, right key = blue). In the *visual localization* task, a white dot emerged close to the borders of the space's quarters between two vertical boundary lines 28 cm apart. The participants indicated with the four buttons of the keypad in which of virtual quarters they localized the dot.

In all auditory and visual tasks, each trial lasted 3.0 s starting with a silent period between 100 and 900 ms to prevent automatic responses and to maintain the participants' alertness. After the silent period, the stimuli were applied. In each task, the different kinds of trials occurred in pseudo-randomized order to avoid expectation effects. The participants could respond within 1.8 s after stimulation onset on always the same 4-button keypad. In pitch discrimination and pitch contour perception one key, in locus-pitch perception two keys for indicating pitch changes at the left and right ear, and during pitch identification and the visual tasks four keys were used; keys that were unneeded were capped to avoid distraction. In each task, the maximum score was 60.

2.4. Assessment of potential covariates

A semi-structured interview assessed sex, age, and educational field of study. For enquiry of experiences with making music, the experimenter asked "Do or did you play a music instrument or sang in a choir?" Since all German pupils received such lessons in school, we considered only practice or lessons in addition to regular school education. Further questions were "For which period do you play music?" "Did you receive lessons and how long?" "Do you play music currently?" Similar questions enquired performing arts. Criterion for the assignment to the music or arts group was practicing regularly on an advanced level for at least two years.

2.5. Experimental procedure

After the interview and ensuring right-handedness, hearing, and color vision, the participants performed the perception tests. The perception assessment ranged between 8:30 am and 20:00 pm with a bimodal distribution: in the majority of participants, perception testing started at 10:30 am or at 16:30 pm. The experimenter explained each task in detail and introduced the stimuli using a practice program on computer without recording the responses. For standardization, each participant performed 60 practice trials in each test before data acquisition. During visual testing, the ambient light was dimmed. The auditory and visual tests occurred blocked for the sensory domains; the order of auditory and visual blocks and of the tests within the blocks was pseudo-randomized and balanced. Finally, the participants attended to the intelligence test. The whole procedure lasted three hours. Between each perception task was a short break of 2 min; between perception assessment and intelligence test, the participants took a rest of 10 min.

2.6. Statistics

The analyzed data sets were complete for each participant. The score in the Raven's Advanced Progressive Matrices Set II was the sum of correct answers according the test manual (Heller et al.,