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**Cross-cultural similarities and
differences in perception of
tasks of varying complexity**

Habilitation Thesis

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Abstract

This Habilitation thesis investigates when and why cultures differ in visual perception and cognition across tasks of increasing complexity, and when such differences attenuate. The program integrates eight studies: (I) a methodological review of adaptation/equivalence principles in cross-cultural testing; (II–III) psychometric evaluation and cross-national invariance testing of self-construal/individualism–collectivism scales; and (IV–VIII) empirical comparisons across minimal perceptual tasks with multilevel reaction-time (RT) modeling, eye-tracking during free viewing of complex 2D scenes, immersive 3D virtual-reality (VR) viewing, and categorization of multivariate map symbols. Data were collected from over 4,000 participants spanning Central Europe, East Asia, the Western Balkans, Türkiye, and Ghana. Three consolidated findings emerge. First, cultural differences are real but selective and task/index-dependent. Robust object–context allocation differences appear in eye-tracking (2D and VR), with East Asian samples allocating relatively more attention to background than several Central European, Turkish, and Ghanaian samples; effects are metric-specific (e.g., dwell time vs. fixation count) and not universal. Minimal tasks (hierarchical/embedded figures) show detectable but modest, context-sensitive differences; country rank-orders are task-specific rather than unitary. Second, convergence across methods is limited. Hierarchical-figures measures do not reliably track eye-tracking indices within individuals, and latent profiles do not support a single analytic–holistic “metastyle.” Where convergence occurs (e.g., global–local predicting analytic symbol categorization), it is selective. Third, popular predictors travel unevenly. Self-construal/INDCOL instruments show suboptimal factor structures and weak cross-national invariance in some contexts, and exhibit only modest links to behavior; macro-level Hofstede/Schwartz indices act as blunt, inconsistent predictors in multilevel models. Methodologically, the thesis foregrounds measurement equivalence as a prerequisite for cultural inference and combines harmonized protocols with RT modeling and overt attention measures to separate decision dynamics from attentional allocation. Substantively, the results calibrate the analytic–holistic framework: culture shapes perception via multiple, partially independent routes.

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1 Goal and structure of the thesis

In recent decades, the rapid development of technology and the widespread use of the Internet have profoundly transformed how information is accessed, shared, and interpreted. This shift marks not only a movement from traditional media such as newspapers and television to digital platforms and social media but also a change in the very nature of communication itself - toward greater interactivity and immersion (Guo, 2025). Within this transformation, visual communication has become increasingly prominent as a universal and powerful channel of information exchange. It allows information to be transmitted more efficiently and facilitates emotional and cognitive engagement. Technological advances, including the integration of artificial intelligence, big data, and immersive technologies such as virtual and augmented reality, have further expanded the reach and impact of visual communication, making our world more visual than ever before (Guo, 2025). At the same time, these developments pose challenges: they demand messages that are not only effective but also inclusive and sensitive to diverse cultural contexts.

From a psychological perspective, visual perception and attention are fundamental cognitive processes that underlie successful interaction with increasingly complex informational environments. Das (2007) emphasizes that the ability to locate, recognize, and act upon objects of interest within a visual scene recruits a number of complex processes central to everyday functioning. As information environments become more visually dense and technologically mediated, understanding the mechanisms of visual attention and perception becomes even more critical.

Importantly, these perceptual and attentional processes are not culturally uniform. Cross-cultural research demonstrates that culture shapes how people allocate attention and interpret visual input. Boduroglu, Shah, and Nisbett (2009) showed that East Asian participants tend to adopt a more holistic mode of attending to the perceptual field, whereas Western participants focus more analytically on salient focal objects when detecting change. Such differences in visual attention strategies highlight how cultural background systematically influences the processing of visual information. Similarly, Gonthier (2022) demonstrated that performance on widely used visuo-spatial reasoning tasks, such as Raven's matrices (that were by some considered a culture-free, or culture-fair test of intelligence), is shaped by cultural differences in processing and manipulating visual information. This finding challenges the assumption of cultural neutrality in visuo-spatial tests and underscores the importance of considering culture in the interpretation of perceptual and cognitive performance.

Taken together, these insights illustrate both the increasing centrality of visual communication in today's technologically mediated societies and the significant role of cultural factors in shaping perceptual and attentional processes. This dual perspective, technological and cultural, provides the motivation for investigating how individuals from different cultural backgrounds perceive tasks of varying levels of complexity. Understanding these similarities and differences is essential not only for advancing theories of cognition and culture but also for

developing practical applications in education, cross-cultural communication, and human-computer interaction.

This habilitation thesis aims to investigate cross-cultural similarities and differences in visual perception and cognition across tasks of varying complexity. The presented studies are mainly grounded in psychometric and experimental traditions, the goal is to provide a complex summary of their findings, point out limitations and discuss future directions of the discipline.

The thesis is organized in the following fashion. In the Introduction I want to provide a concise overview of the State-of-the Art starting with an overview of earlier theories and methods of cross-cultural perceptual research followed by an overview of theory of holistic and analytic cognition including subchapter on the assumed predictors of cross-cultural differences in perception and cognition. Introduction thus provides a framework of the studies conducted by the author of the thesis. The next section summarizes the studies, author contribution and methodology of the studies. In the final section, the findings of the studies used as a basis of this thesis are discussed, separate sections are dedicated to critical reflection of their results, their synthesis, limitations of the approach used in the studies, and suggestions on how to improve the research in the field. In the Appendix reader can find all studies used as a core of this thesis.

2 Introduction

2.1 Theories and methods in cross-cultural cognitive research

Before focusing on specific theories, it would be beneficial for the reader to to acquire an overview of the development of theories and methods of cross-cultural psychological research in perception and cognition.

2.1.1 Early foundations

The study of perception across cultures emerged at the intersection of anthropology and psychology in the early 20th century. Among the pioneering researchers we can count Rivers (1905) who led an expedition to Torres strait islands to study various cognitive phenomena such as visual acuity, color vision, visual afterimages and perception of illusions.

A large body of early research focused on perception of depth, more specifically, on the interpretation of depth cues. Hudson's (1960) studies in South Africa, where participants from rural African groups struggled with depth cues in two-dimensional images. Deregowski (1972, 1980) provided a systematic review of cross-cultural findings on pictorial perception and visual illusions, showing that interpretation of two-dimensional pictures depended strongly on cultural exposure to representational art.

Work of Segall, Campbell, and Herskovits (1963), later synthesized by Segall, Dasen, Berry, and Poortinga (1990). They investigated visual illusions (e.g., Müller-Lyer, horizontal-vertical, and Ponzo illusions) across dozens of cultural groups. Their "*carpentered world*" hypothesis proposed that individuals living in environments dominated by rectangular structures, such as urban Western environments, were more susceptible to illusions based on perspective cues. In contrast, participants from non-industrialized societies, with fewer such environmental cues, showed reduced susceptibility. These observations challenged universalist assumptions of perception as a purely biological process and opened the door for the idea that perceptual mechanisms interact with ecological and cultural contexts.

This idea was further developed by Berry (1968, 1971) and his colleagues (Berry, Poortinga, Segall, & Dasen, 2011) who proposed an *ecocultural approach*, which states that ecological factors (e.g. climate, geography, subsistence) interact with sociocultural factors (e.g. social structure, division of labor, values) to shape cognitive and perceptual strategies. For example, hunter-gatherer groups may for example develop superior spatial navigation abilities compared to agricultural groups, whose ecological demands foster different attentional priorities, as demonstrated in later empirical studies (Uskul, Kitayama, & Nisbett, 2008). The macro-level factors should therefore not be neglected but systematically studied.

2.1.2 Gestalt laws of perceptual grouping

The research mentioned in the previous chapter was *empiricistic* by nature stressing out the importance of sensory experience on forming perceptual strategies. Gestalt principles (or laws) stem from a *nativistic* tradition; experience can be ignored to a large extent because all information needed for a successful processing of a perceptual stimulus are included in the stimulus. The details of the laws of Gestalt are beyond the scope of this thesis and are in higher detail described elsewhere (Čeněk, 2016; Čeněk & Šašinka, 2015); Wagemans et al., 2012a).

The laws of Gestalt were introduced in 1923 by M. Wertheimer (Wertheimer, 1923, cited in Wagemans et al., 2012a). They represent fundamental principles according to which discrete perceptual elements are grouped into higher-order *wholes* to form the most coherent and harmonious configurations (principle of *Prägnanz*). Originally the German word *Gestalt* represents a “*good shape*” that has higher probability of grouping than other possible perceptual configurations. The classical laws of Gestalt such as Symmetry, Similarity, Closure, or Proximity were later enriched by formulation of additional principles such as Synchrony, Common region, or Connectedness (Palmer & Beck, 2007; Palmer & Brooks, 2008; Palmer & Rock, 1994) and introduce grouping of elements by motion or changes of luminance. Newer approaches (Palmer, 2002; Palmer, Brooks, & Nelson, 2003) argue that the results of grouping processes (Gestalts) are influenced not only by the structure of elements projected onto the retina, but also by later cognitive operations. This is an important element in the theory: Gestalts are not formed in a one-shot manner at the level of the retinal image or primary processing, but develop throughout the perceptual process. The more contemporary authors thus abandon the strictly nativistic approach.

If we should name one element of the Gestalt theory that influenced cross-cultural research on perception and cognition, it would have to be the principle of holism. The duality of the whole (Gestalt) and its parts is central to Gestalt psychology. According to Gestalt, the natural human tendency is holistic perception—elements are not perceived in isolation but within higher cognitive units. Contemporary (Wagemans et al., 2012b) Gestalt-based research operationalizes this duality as *global vs. local processing*. In his research Navon (1977) focused on perception of hierarchical visual scenes and quite famously formulated a metaphor that we “*see the forest before the trees*”. This metaphor should give an answer to the question in which order we perceive complex hierarchical visual scenes - whether we perceive first the whole (the forest; the global level), or the elements of the scene (the trees; the local level). He believed that the whole comes first and termed this a *global precedence effect* (Navon, 2003; Navon, 1977). In a sense this is the original Gestalt theory turned upside down, in other words, this is a conceptual shift because a complex visual scene is not constructed by summing its parts; rather, it is initially perceived as a relatively vague whole and only then structured by attentional processes - as attention targets components, the scene becomes clearer, sharper, and more detailed, with specific spatial relations (Čeněk, 2016).

Global precedence was empirically tested using compound letters (currently quite commonly referred to as “*Navon task*”). In this task (Navon, 1977) participants are presented with a series

of hierarchical stimuli (e.g. large letters composed of smaller letters) to identify either the global (large) or local (small) letter. Typically, the speed of processing of each type is measured. However, the relative size of this effect can vary between individuals, groups, and in some cases turn into a local precedence (e.g. by increase of spacing between local elements; Čeněk, 2016).

Navon task was previously used to test whether there are any cross-cultural differences in global and local processing. For example Davidoff, Fonteneau, & Fagot (2008) found that members of Himba tribe in northern Namibia would not exhibit the global advantage and in comparison with a sample of British participants processed stimuli more locally. A follow-up study (Caparos, Linnell, Bremner, de Fockert, & Davidoff, 2013) with British and Himba samples suggests that the Himba exhibit strong control over attentional processes, who in some experimental settings performing relatively better on both local and global tasks. Other cross-cultural studies using this method typically compare “Western” cultures with Southeast/East Asian cultures. While some of the studies indicate global advantage (Kiyokawa et al., 2012; McKone et al., 2010) of East Asians, others show mixed or opposite results (Oishi et al., 2014).

2.1.3 Cognitive styles and field dependence

There is another group of theories that, apart from Gestalt, formed current cross-cultural research on perception and cognition. This group of theories can be labeled as *cognitive styles*. Cognitive styles can be defined as consistent patterns in individuals cognitive functioning: perceiving, remembering, thinking, and problem solving (Messick, 1976), or heuristics that can be identified at all levels of information processing and that individuals use to process information from their environment (Kozhevnikov, 2007). Detailed classification of cognitive styles is beyond the scope of this thesis and can be found in Čeněk (2016), or Kozhevnikov (2007).

Probably the most studied cognitive style, field independence, was defined by Witkin (e.g. Witkin et al., 1977; Witkin & Goodenough, 1977). The central idea of the theory is that at both cognitive and psychological and social levels individuals differ in the extent to which they control their environment and get influenced by their environment. More specifically, there are individual differences in people's ability to, for example: a) differentiate objects in complex scenes (field independent individuals well, field dependent individuals poorly), b) be able to ignore surrounding of target object (field independent well, field dependent poorly), c) react to stress (field independent relatively weaker stress reaction), d) are conformist (field independent relatively less), or e) differentiate self from others (field independent relatively more). Originally, field independence is understood as more desirable than field dependence. In later stages, the concept of field dependence is value-neutral as a process of psychological differentiation (Goodenough & Witkin, 1977) primary emphasis on the influence of social and ecocultural factors which can be considered novel in perception research.

Among these factors they count child-rearing practices in the family—specifically, the degree to which obedience and conformity versus autonomy are required of the child (Witkin, 1979).

Cross-cultural studies compared many cultural and ethnic groups. For example, respondents from Peru and the USA (Gruenfeld, Weissenberg, & Loh, 1973), Cuba and the USA (Britain & Abad, 1974), various communities in Mexico (Ramirez & Prince-Williams, 1974), Anglo-Americans and Latino-Americans in the USA (Buriel, 1975), or communities in the Netherlands, Italy, and Mexico (Witkin et al., 1974). These studies indicate that children raised to be independent and autonomous tend to become field-independent, whereas children from families enforcing obedience and conformity and restricting the child's activities tend to become field-dependent (Witkin, 1979).

Among other factors that have been studied within the paradigm the authors count the degree of liberalism or conservatism within the society and its implications in differences in pressure toward conformity, level of delineation of social roles, or level of social hierarchy. Traditional societies tend to foster field dependence, while liberal societies tend to stimulate the development of a field-independence (Goodenough & Witkin, 1977; Witkin & Berry, 1975). Means of subsistence and resource accumulation distinguish between nomadic groups, hunters and gatherers and agricultural societies. While the former do not create substantial food stores, the latter typically accumulate food. In the case of hunters-gatherers this empowers higher individual autonomy and lack of centralized social structures that leads to field independence. In contrast, agrarian societies tend to exhibit higher conformity, centralization, and social stratification, which foster field dependence (Goodenough & Witkin, 1977). Other predictors of differences in cognition were examined both intra- and cross-culturally, such as socioeconomic status and parents' education (Cakan, 2003), the magnitude of sex differences in performance (Dor-Shav, 1984; Pande, 1970), achievement-related values (Gruenfeld, Weissenberg, & Loh, 1973), and individualism-collectivism (Kühnen et al., 2001).

The genesis and development of methods to test field independence is relatively long and interesting starting with mechanical contraptions such as body-adjustment test or rotating-room test based on rotation of a stimulus or participants body where subjects were instructed to interpret conflicting visuo-spatial cues in a visual scene (e.g. Witkin, 1949). These earlier methods were followed by a relatively popular rod-and-frame test (e.g. Witkin & Goodenough, 1977) where respondents are instructed to determine position in which "a rod" is positioned vertically while simultaneously ignore position of "a frame" that serves as a distractor. Relatively later, in the 60s and 70s, so-called embedded figures test (EFT) became popular in experimentation within the field-independence research. In EFT participants are presented with a simple geometric target and their task is to identify the target within a more complex geometric figure (Witkin, 1950).

2.2 Theory of holistic and analytic cognition

Theory of holistic and analytic cognition is a more contemporary cross-cultural theory used in cognitive and perceptual research. Nisbett and Masuda (2003) popularized the distinction

between holistic and analytic cognition, which has since become one of the most influential frameworks in cross-cultural psychology. Building on the earlier comparative studies, contemporary cross-cultural psychology has identified systematic cultural differences in broader cognitive strategies. The authors claim that there are two distinctive modes of processing: 1) analytic cognition, prevalent in Western societies, and 2) holistic cognition, more common in East Asian societies. This framework builds on earlier concepts of field dependence and independence (e.g. Witkin & Goodenough, 1977). As mentioned above, field-independent individuals are more likely to separate objects from their backgrounds, a style congruent with analytic cognition. By contrast, field-dependent individuals perceive objects in relation to their context, resembling holistic processing.

2.2.1 Past research - scope of the theory

However, this theory broadens its scope and does not focus mostly on “lower” processes such as object formation, differentiation and separation. Empirical studies usually compare two samples, typically North Americans and Western Europeans (e.g. Canada, USA, UK) and East Asians (China, Japan, South Korea) and mostly provide converging evidence of the theory. At this point we can go through some of the studies within the holistic-analytic paradigm, listed approximately from lower perceptual processes to higher cognitive processes.

- 1) **Global vs. local attention.** McKone et al. (2010) used hierarchical stimuli (Navon-type) to compare global/local biases across racial/cultural groups. East Asian participants showed a stronger global-processing advantage than Caucasian Westerners, underscoring reliable group differences in attentional distribution across spatial scales.
- 2) **Object-background differentiation.** Kühnen et al. (2001) compared the Embedded Figures Test across the United States, Germany, Russia, and Malaysia. Cross-cultural variation in locating embedded shapes suggested reliable differences in field dependence-independence between individualist (USA, Germany) and collectivist (Russia, Malaysia) societies.
- 3) **Visual attention to focal objects vs. context.** Chua, Boland, and Nisbett (2005) recorded eye movements while Chinese and American observers viewed complex scenes. Americans fixated more on focal objects; Chinese viewers made relatively more context-oriented fixations, evidencing cultural modulation of overt attention. Masuda and Nisbett (2001) compared American and Japanese students in attention to focal objects and background when perceiving underwater scenes. American participants reported more analytical answers (e.g. “*I see fish.*”) focusing on focal objects while Japanese were more likely to give holistic answers (e.g. “*I see underwater life.*”) focusing on the whole scene.
- 4) **Change detection.** Masuda and Nisbett (2006) used change-blindness tasks with perceptually rich vignettes. Americans were more sensitive to focal-object changes, whereas East Asians were relatively more sensitive to background/context changes. Masuda, Ishii, and Kimura (2016) measured eye movements in a visual flicker paradigm

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- with European Canadians and Japanese. When focal changes were made highly salient (strong bottom-up cues), cultural differences in change detection and eye-movement patterns largely disappeared; however, eye-movements in no-changes trials revealed more divergence in focal object fixations - European Canadians fixated the objects comparatively longer.
- 5) **Absolute vs. relative judgments.** Kitayama et al. (2003) introduced the Framed-Line Test comparing accuracy in absolute (context-independent) vs. relative (context-dependent) line-length reproduction. Americans were more accurate on absolute judgments; Japanese were more accurate on relative judgments.
 - 6) **Scene memory.** Mickley Steinmetz et al. (2018) examined recognition for items vs. backgrounds under varying emotional intensity and congruency. Americans showed better item recognition compared to East Asians.
 - 7) **Object categorization.** Ji, Zhang, and Nisbett (2004) compared Chinese-English bilinguals (tested in English or Chinese) and European Americans on categorization tasks. Across tasks, Chinese participants showed more relational/contextual grouping, whereas European Americans were more taxonomic; language had modest, task-specific effects - Mainland Chinese and Taiwanese tested in English were more relational than the same groups tested in Chinese. This indicates a role of language in object categorization. Similar results were obtained by Chiu (1972) that showed that Chinese children were more likely to group objects relationally, whereas American children grouped them categorically.
 - 8) **Perception of relationships** (covariation). Ji, Peng, and Nisbett (2000) tested North American and East Asian participants on covariation detection and perception judgments linking elements in the environment. East Asians showed greater sensitivity to relationships and contextual covariation, whereas North Americans emphasized agency/control and object-focused judgments.
 - 9) **Causal attribution.** Miyamoto and Kitayama (2002) showed that cultural differences in correspondence bias depend on how "*attitude-diagnostic*" a behavior is. Japanese participants made fewer dispositional attributions than Americans when behavior was socially constrained (had low diagnosticity); differences attenuated when behavior was highly diagnostic. Masuda and Kitayama (2004) manipulated perceived situational constraints in attitude-attribution tasks with Japanese and USA samples. When behaviors were clearly constrained, Japanese participants reduced dispositional attributions more than Americans, demonstrating stronger context sensitivity in causal inference. Morris and Peng (1994) found that American participants explained social events by attributing causes to individual dispositions, whereas Chinese participants emphasized situational factors.
 - 10) **Reasoning.** Peng and Nisbett (1999) used conflict scenarios and argument evaluation to test dialectical vs. non-dialectical reasoning. Chinese participants were more likely than Americans to accept seemingly contradictory propositions and to seek middle-way resolutions, consistent with dialectical cognition (as an indicator of more holistic thinking). Norenzayan, Smith, Kim, and Nisbett (2002) ran multiple experiments contrasting "formal/analytic" versus "intuitive/holistic" reasoning (e.g., syllogisms with unbelievable conclusions, similarity-based induction). East Asian participants showed

relatively greater comfort with intuitive/holistic strategies, whereas European Americans favored rule-based analytic solutions - though instructions and task framing could shift preferences.

It should be noted that the above-referenced studies are not exhaustive and are partially “*cherry-picked*” for the purpose of this thesis. There are studies out there published between 2000 and 2015 that either produced null results, or used more diverse samples. We will get back to that matter later.

2.2.2 Predictors of differences in perception and cognition

A compelling cross-cultural theory must explain not only what differs across cultures but also why. Predictors of holistic versus analytic perception span multiple, interacting levels: historical–philosophical traditions, ecocultural and structural conditions, sociocultural and developmental factors, and modernization/sampling contexts—and should be interpreted as converging influences rather than single causes (Nisbett et al., 2001; Nisbett & Miyamoto, 2005; Gutches & Rajaram, 2023).

Historical context and philosophical traditions. Some studies hypothesize that cultural differences in cognition are linked to enduring intellectual lineages. Classic syntheses argue that Greek philosophical emphases on logic, categorization, and individual agency scaffold analytic processing, whereas Confucian, Taoist, and Buddhist emphases on harmony, relationality, and context support holistic processing (Nisbett et al., 2001; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). These legacies are visible in contemporary tasks that require allocating attention to objects vs. relations or privileging rules vs. context (Nisbett & Masuda, 2003). At the level of reasoning, dialecticism—a tolerance for apparent contradiction and preference for middle-way resolutions—has been repeatedly documented in East Asian samples relative to North Americans (Peng & Nisbett, 1999). Relatedly, preferences for formal/analytic vs. intuitive/holistic reasoning vary by culture and task framing, with East Asian participants often showing greater acceptance of intuitive solutions and Americans more rule-based preferences (Norenzayan et al., 2002). These philosophical legacies thus provide a conceptual backdrop that helps explain cross-cultural differences in categorization, attribution, and attentional selection reported across literatures (e.g., Ji et al., 2004; Chua et al., 2005; Kitayama et al., 2003). Importantly, historical traditions are not destiny: contemporary social environments can amplify, attenuate, or reshape these tendencies (Gutches & Rajaram, 2023). Regional syntheses beyond the East–West dyad (e.g., Latin America; Central and East European; or Mediterranean patterns) demonstrate that cognitive styles reflect locally specific histories and institutions rather than a single civilizational split (de Oliveira & Nisbett, 2017; Uskul et al., 2023; Varnum et al., 2008).

Ecocultural context and dimensions of culture. Ecocultural perspectives propose that subsistence demands and social structure influence habitual attention and reasoning Berry (1968, 1971), Berry et al. (2011). For example, work with the Himba shows a relative local

advantage in hierarchical processing compared to British participants, interpreted in light of pastoral lifeways that reward fine-grained discrimination (Davidoff et al., 2008). Moreover, pastoral lifeways can prioritize item-level discrimination and autonomy; agrarian systems often involve coordination and hierarchy, potentially reinforcing context sensitivity (Witkin & Berry, 1975; Witkin, 1979; Davidoff et al., 2008). More broadly, cross-cultural tightness-looseness (norm strength and sanctioning) varies systematically and relates to conformity pressures that may modulate context sensitivity (Uz, 2015). Other country-level cultural dimension models such as Hofstede dimension of Individualism were hypothesized as potential predictors of differences in information processing (e.g. Kitayama et al., 2003; McKone et al., 2010). It should be noted that most studies use country contrasts aligned with Hofstede (e.g. US vs. East Asia) rather than including national indices into statistical models directly testing them.

Language and socialization. Language supplies categories and grammatical resources that guide attention and relation perception; bilingual and cross-linguistic comparisons show effects of language on categorization and context sensitivity (Ji et al., 2004). Schooling and assessment regimes can encourage rule-based analysis (Peterson & Deary, 2006), whereas other learning environments cultivate context- and relation-oriented processing. Classic differentiation work also underscores parenting and socialization: autonomy-supportive contexts tend to foster field-independence, while obedience and conformity pressures foster field-dependence (Witkin, 1979).

Independent and interdependent self-construal. The last predictor that will be mentioned here is one of the most studied predictors of cross-cultural differences in perception and cognition in recent years - independent and interdependent self-construal. Independent and interdependent self-construals can be considered individual-level equivalent to Hofstede macro-level individualism (see Oyserman et al., 2002). Independent self-construal represents a self-view that emphasizes the individual as autonomous, distinct, and internally guided - prioritizing personal traits, goals, and rights over social roles and relationships. On the other hand, interdependent self-construal is a self-view that emphasizes the individual as connected, relational, and contextually embedded—prioritizing social roles, obligations, and harmony with others.

Classic theory proposes that independent self-views encourage attention to focal objects, rules, and internal attributes (analytic processing), whereas interdependent self-views promote attention to relations, context, and harmony (holistic processing) (Nisbett et al., 2001; Oyserman et al., 2002). Empirically, self-construal differences are linked to perceptual tasks that index context use: in the Framed-Line Test, American participants (more independent) outperform on absolute (context-independent) judgments, whereas Japanese participants (more interdependent) excel on relative (context-dependent) judgments (Kitayama et al., 2003); likewise, East-West contrasts in scene perception show greater object focus vs. background/context sensitivity (Masuda & Nisbett, 2001; Nisbett & Masuda, 2003). Beyond the standard East-West comparison, work in Latin America suggests intermediate or distinctive profiles of Brazilians (de Oliveira & Nisbett, 2017), and recent Mediterranean data show

independence–interdependence patterns that diverge from a simple East-West dichotomy (Uskul et al., 2023).

At the construct level, implicit independence varies across North America, Western Europe, and East Asia (Kitayama et al., 2009), and longitudinal evidence suggests within-person stability in interdependent (vs. independent) social orientation alongside holistic (vs. analytic) cognition (Na et al., 2020). Still, not all findings align neatly with the predictor model: some studies argue that cultural effects cannot be reduced to individual differences (Na et al., 2010), and others report weak or null associations between measured self-construal and holistic/analytic reasoning (Marquez & Ellwanger, 2014).

3 List of studies and authors' contribution

The eight studies included in this habilitation thesis (see Appendix) form a coherent research line. The thesis comprises three sets of studies. Study I is methodological study and focuses on broader methodological issues typical for cross-cultural research. Studies II and III focus on validation of scales of independence and interdependence (or individualism and collectivism), as one of the theoretically plausible predictors of cross-cultural differences in perception and cognition. Studies IV, V, VI, VII, and VIII form the core of the thesis and focus on cross-cultural similarities and differences in perceptual and cognitive processes, using tasks of increasing complexity: from simple perceptual discrimination and reaction time modeling, through eye-tracking in naturalistic scenes and immersive virtual reality (VR), to categorization of symbols.

Note to Study I: The study was originally published in Czech. English translation of the study was conducted by the author and is provided in Appendix.

Note to the Author contribution: In all articles listed below, the Author contribution was approved by both Leading author (Lacko) and principal investigator (Šašinka). The percentages of author contributions are estimated.

STUDY I: Čeněk, J., & Urbánek, T. (2019). Adaptace a ekvivalence testových metod: Inspirace pro psychologické testování minorit v ČR. *Československá psychologie*, 63(1). [The adaptation and equivalence of test methods: An inspiration for psychological assessment of minorities in the Czech Republic]

Author contribution (90%): Leading author, Conceptualization, Writing - Original draft (all parts of the article).

STUDY II: Lacko, D., Čeněk, J., & Urbánek, T. (2021). Psychometric properties of the independent and interdependent self-construal questionnaire: Evidence from the Czech Republic. *Frontiers in psychology*, 12, 564011. <https://doi.org/10.3389/fpsyg.2021.564011>

Author contribution (30%): Conceptualization, Methods, Investigation (participant recruitment), Writing - Original draft (parts of Introduction, Methods and Discussion), Writing - Review and Editing.

STUDY III: Lacko, D., Čeněk, J., Točík, J., Avsec, A., Đorđević, V., Genc, A., ... & Subotić, S. (2022). The necessity of testing measurement invariance in cross-cultural research: Potential bias in cross-cultural comparisons with individualism–collectivism self-report scales. *Cross-Cultural Research*, 56(2-3), 228-267. <https://doi.org/10.1177/10693971211068971>

Author contribution (25%): Conceptualization, Methods (coordination of translations and data gathering), Investigation (Czech participants), Project administration (communication with international partners), Visualizations (graphs), Data curation, Writing - Review and Editing.

STUDY IV: Lacko, D., Čeněk, J., Arıkan, A., Dresler, T., Galang, A. J., Stachoň, Z., ... & Šašík, Č. (2024). Investigating the geography of thought across 11 countries: Cross-cultural differences in analytic and holistic cognitive styles using simple perceptual tasks and reaction time modeling. *Journal of Experimental Psychology: General*, 154(2), 325–346. <https://doi.org/10.1037/xge0001685>

Author contribution (20%): Conceptualization, Methods (co-creator of all administered methods), Investigation (laboratory data gathering in Ghana, Taiwan, Turkey), Data curation, Writing – Review and Editing.

STUDY V: Čeněk, J., Tsai, J. L., & Šašík, Č. (2020). Cultural variations in global and local attention and eye-movement patterns during the perception of complex visual scenes: Comparison of Czech and Taiwanese university students. *Plos one*, 15(11), e0242501. <https://doi.org/10.1371/journal.Pone.0242501>

Author contribution (65%): Leading author, Conceptualization, Methods (author), Formal analysis, Data curation, Writing - Original Draft (all sections).

STUDY VI: Čeněk, J., Halámková, D., Čaha, J., Lacko, D., Kalenská, P., Stachoň, Z., ... & Šašík, Č. (2025). Cross-cultural analysis of eye-movement patterns in visual scene perception: a comparison of seven cultural samples. *Scientific Reports*, 15(1), 28574. <https://doi.org/10.1038/s41598-025-12724-x>

Author contribution (60%): Leading author, Conceptualization, Methods (author), Formal analysis, Data curation, Writing - Original Draft (all sections).

STUDY VII: Šašíková, A., Čeněk, J., Ugwitz, P., Tsai, J. L., Giannopoulos, I., Lacko, D., ... & Šašík, Č. (2023). Exploring cross-cultural variations in visual attention patterns inside and outside national borders using immersive virtual reality. *Scientific Reports*, 13(1), 18852. <https://doi.org/10.1038/s41598-023-46103-1>

Author contribution (55%): Leading author, Conceptualization, Methods (co-author), Formal analysis, Data curation, Writing - Original Draft (all sections).

STUDY VIII: Lacko, D., Šašík, Č., Čeněk, J., Stachoň, Z., & Lu, W. L. (2020). Cross-cultural differences in cognitive style, individualism/collectivism and map reading between Central European and East Asian University students. *Studia Psychologica*, 62(1), 23-43. <https://doi.org/10.31577/sp.2020.01.789>

Author contribution (15%): Methods (co-creator of CFT/Navon method), Writing - Review and Editing.

4 Methodology

This thesis is based on eight published studies. With the exception of **Study I** (a review), all employ a quantitative design, using questionnaire data, experimental data (e.g., correctness of responses, reaction times), or a combination of survey and experimental data. Detailed descriptions of each study can be found in the respective Method sections in the Appendix. Here, only a brief summary of the methods and samples is provided.

Data for **Studies II, IV, VI, VII, and VIII** were collected as part of the Czech Science Foundation project *The Influence of Socio-Cultural Factors and Writing System on Perception and Cognition of Complex Visual Stimuli* (GC19-09265J). Data for Study V were additionally co-funded by the Ministry of Education, Taiwan, through the project *Comparison of Visual Perception and Eye-Movement Patterns in Complex Visual Stimuli of Taiwanese and Czech Participants*. Data for Study III were obtained within Czech Science Foundation project *Mutual perception of acculturation preferences in majority and immigrants: An intergroup perspective* (GA20-01214S).

Study II was aimed at validation of Czech versions of two scales of independent and interdependent self construal, resp. individualism and collectivism (SCS, INDCOL). To do that, we gathered data from 330 Czech participants and calculated factor structure, reliability and convergent validity between both measures.

Study III was focused on both validation and measurement invariance across countries of another independent and interdependent self construal scale (IISS). In 2020 data from 1927 participants from seven countries (Albania, Bosnia and Herzegovina, Croatia, Czechia, Macedonia, Serbia, Slovenia) were gathered.

Study IV adopted a multi-method approach and was focused on comparison of cognitive patterns of multiple cultural samples using relatively simple cognitive tasks (two hierarchical figures, embedded figures). Using multilevel modeling the study tried to estimate the influence of country-level variables (Hofstede and Schwartz dimensions) on cognition. The study was conducted on a relatively large sample of 993 participants from 12 cultural groups of students. Data were collected in both laboratory and online settings.

Studies V and VI both focused on perception of 2D visual scenes using eye-tracking methodology, more specifically, on visual attention to objects and background. In Study V we gathered data of 129 Czech and Taiwanese participants. Study VI was a conceptual replication of Study V and compared attention patterns of 408 participants from 7 cultural samples.

Study VII adopted a similar design as Studies V and VI, free-viewing of 3D visual scenes with eye-tracking, but extended it into a virtual reality environment. Within this study, data from 242 participants from five cultural groups were gathered.

Finally, in **Study VIII** an independent- and interdependent-self scale was administered together with a hierarchical figures task and a task on categorization of multivariate map symbols. The methods were administered on a sample of 103 Czech and Chinese/Taiwanese respondents.

5 Discussion

The eight studies included in this habilitation thesis tell a cumulative story about when and why cultures differ in perception and cognition - and when they do not. The main guiding question was not only whether cross-cultural differences appear on particular tasks, but also on constructs that might predict these differences (**Study II** and **III**) across tasks that range in complexity: simple perceptual discrimination with reaction-time (RT) modeling (**Study IV**), free viewing of complex 2D scenes with eye tracking (**Studies V–VI**), immersive viewing of 3D scenes in virtual reality (Study VII), and categorization of multivariate symbols (**Study VIII**). Along the way, keeping in mind potential measurement and adaptation issues that commonly derail cross-cultural inference were addressed (In line with the principles from Study I).

Discussion is organized thematically. I first anchor the program in the methodological foundations (**Study I**), then examine individual-level (**Studies II–III** and **VIII**), and macro-level predictors (**Study IV**) followed by the core empirical contrasts across increasing task complexity (**Studies IV–VIII**). Discussion is concluded by Limitations and Future directions subchapters.

5.1 Individualism-collectivism as a predictor of differences in cognition

Cross-cultural differences are only as trustworthy as the methodological scaffolding that supports them. **Study I** reviewed adaptation and equivalence procedures and emphasized that construct, method, and item-level equivalence are prerequisites for any substantive cross-cultural claim. This perspective informed the later studies in two ways. First, it motivated prospective design choices (e.g., harmonized instructions, stimulus selection, and task timing) in Studies IV–VIII. Second, it motivated psychometric due diligence for predictors: Studies II–III tested the factor structure, reliability, and cross-national comparability of self-construal measures before using them as explanatory variables. In short, Study I was not an add-on; it framed the logic of inference for the entire program.

If cultural differences in perception and cognition are theoretically connected to self-construal (independence vs. interdependence), then our predictor must be measured well. **Study II** validated Czech versions of two widely used instruments tapping independence–interdependence/individualism–collectivism (N = 330). We used the previously adapted INDCOL (Individualism-Collectivism) scale (originally Singelis et al., 1995; adapted by Bartoš, 2010) together with newly adapted SCS (Self-Construal Scale; Vignoles et al., 2016). It should be noted that INDCOL was a reduced version of the original - 3 items had to be deleted to obtain at least satisfactory reliability and factor structure of the Czech version. However, in the original Czech adaptation only exploratory factor analysis (EFA) was used without a subsequent verification by confirmatory factor analysis (CFA). SCS by Vignoles (2010) is an impressive attempt to create an almost “globally universal” scale of individualism and collectivism

including participants across 55 cultural groups using both EFA and CFA techniques. However, CFA fit was suboptimal and metric invariance was not tested.

The results of **Study II** showed that the Czech adaptation of SCS had, although relatively good reliability of subscales, less than ideal factor structure with multiple item-subscale cross-loadings and borderline values of fit indices. The reliability of INDCOL subscales was not satisfactory. Convergent validity of both measures was also tested. Although the directions of correlations between the individualism and collectivism subscales was as expected, the correlation coefficients were relatively small and sometimes non-significant. In conclusion, none of the scales was deemed usable for further research with Czech samples lacking sufficient psychometric properties. Without a theoretically plausible factor structure and reliability a cross-cultural invariance of the scales is hardly possible.

Study III broadened the scope, testing another potentially useful instrument for individual-level individualism and collectivism measurement - the two-dimensional, 42-item IISS (Independent and Interdependent Self Scale (IISS; Lu & Gilmour, 2007). Data were gathered across seven countries in Southern and Central Europe (N = 1,927). The critical step here was examining not just the factor structure and reliability, but also the measurement invariance across the countries (Albania, Bosnia and Hercegovina, Croatia, Czechia, Macedonia, Slovenia, Serbia). When testing measurement invariance Czech sample needed to be removed from all further analyses because of the entirely different factor structure. Furthermore, the scale needed to be reduced significantly to 10-item scale for the remaining six countries to establish configural invariance.

Before conducting a more sophisticated psychometric analysis in **Study III** we used the IISS in **Study VIII** that investigated potential link between scores in Compound Figures Test (CFT), a method using Navon hierarchical figures (Navon, 1977) for investigation of global and local distribution of attention, and categorization of multivariate map symbols (more on the results of **Study VIII** later. All methods were administered on samples of 53 Czech and 45 Chinese participants (both from mainland and Taiwan). Across samples, internal reliability seemed to be sufficient to use independence and interdependence scores as predictors. However, contrary to the assumptions, IISS did not discriminate between Czechs and Chinese in interdependence, only independence scores differed. The IISS scores were a relatively weak predictor of local and global processing.

These results suggest that there is something wrong with scales of individualism and collectivism, one of the most widely studied constructs in cross-cultural psychology, when used outside of the countries they were originally constructed for, more specifically when used in Czechia and countries of Western Balkan. It seems that the construct is partially different in these countries, or there is at least certain bias at the level of items (DIF), and its discriminative power is uncertain. Moreover, these outcomes align with the broader literature on self-construal measurement and its links to cognition. Meta-analytic and conceptual reviews caution that "individualism–collectivism" is not a single latent dimension, that scale content often blends heterogeneous facets, and that correlations with behavioral/cognitive outcomes

are smaller and less consistent than folk theories suggest (see Oyserman et al., 2002; Vignoles et al., 2016; Lux et al., 2021; Marquez & Ellwanger, 2014). Recent multi-wave work also finds low cross-sectional correlations between social-orientation traits and holistic-analytic style measured within individuals, even when both show within-person stability (Na et al., 2020). In other words, self-report self-construal and cognitive styles commonly travel on separate tracks.

Mainly because of the above-mentioned issues with reliability of individualism/self-construal scales in Czech, and theoretical concerns about the link between individual level independence/interdependence, the idea of using them directly as predictors in the follow-up studies was abandoned. In **Study IV** country-level culture scores were treated (Hofstede et al., 2010; Schwartz, 2008) as Level-2 predictors of performance on minimal perceptual tasks (hierarchical/local-global figures; embedded figures) modeled with multilevel reaction times (RT) or accuracy analyses. The basic approach was straightforward: participant-level outcomes (accuracy, RT summaries, and - where applicable - RT-distribution parameters) were modeled with participant random effects and country random intercepts; country scores then entered as between-country regressors. I also probed cross-level interactions with task conditions (e.g., global vs. local targets) to test whether macro indices moderated the global-local balance. Results show that the relationships were modest and inconsistent across tasks and settings:

Several Hofstede dimensions (e.g., individualism-collectivism, long-term orientation, uncertainty avoidance) and Schwartz values (e.g., embeddedness vs. autonomy, hierarchy vs. egalitarianism) showed occasional associations with global-local performance, but no index provided a stable, meaningful predictor across outcomes (e.g. positive associations with both analytic and holistic subtests). Effects that appeared in one model tended to weaken or disappear for example when switching from accuracy to RT/latency parameters. In conclusion, macro-indices appear to be blunt instruments for predicting where and how those differences surface in low-level perceptual decisions.

5.2 Cross-cultural differences in cognition at different levels of complexity

Studies IV-VIII focused on comparisons of student samples from various countries in several tasks focused on global and local processing, separation of object and field and symbol categorization. In this part I want to focus on two issues. First, I want to focus on the observed differences in the holistic-analytic tendencies and how they align with the prevalent theory of analytic-holistic cognition. Second, I want to focus on the convergent validity of these methods. In other words, whether or not the results, when combined, support the theory or not.

5.2.1 Observed differences in perception and cognition across samples

Study IV asked whether analytic vs. holistic tendencies surface on minimal tasks. A multi-task battery (hierarchical figures - search and similarity matching tasks, and a version of embedded figures (Peterson et al., 2006) was assembled and both accuracy and RTs were analyzed using advanced methods of statistical modeling. The study combined lab and online data (N = 993; 12 cultural groups), allowing to assess both setting effects and country-level influences. We did find statistically reliable cross-cultural variation, but the pattern did not line up cleanly with the canonical “East = holistic / West = analytic” prediction; several effects were context-dependent or modest, and country rank-orders were task-specific rather than unitary. Effects appeared but were not large or uniformly stable across tasks or settings.

Studies V and VI tested a classic prediction: cultures put differential weight on focal objects vs. contextual background during free viewing. **Study V** contrasted Czech and Taiwanese university students (N = 129) who were presented with a set of photographs consisting of focal objects and background. With free viewing of complex photographs, we replicated a directionally classic object–context split, but in a metric-specific way: Czech participants made more fixations on focal objects, whereas Taiwanese participants devoted more dwell time to background regions. The classic hierarchical figures task was also administered and task showed no group difference in global advantage in this sample.

Study VI replicated and extended this logic to seven cultural samples (N = 408), using a harmonized protocol and broader stimulus set. Taiwanese observers spent less time on focal objects than all other groups (a “more holistic” pattern), whereas Ghana and Türkiye showed the most analytic allocation by our indices; Central Europeans (Germany, Czechia) did not uniformly diverge from Taiwan on all metrics. Demographic covariates had limited explanatory power; effects were robust but often task/index-specific rather than universal.

Study VII moved from 2D images to 3D, scenes in virtual reality (N = 242; five cultural groups), examining visual attention in different context. The VR setting introduced higher ecological validity and embodiment absent in 2D viewing. Also, the “closeness” of objects within the scenes was manipulated. We again observed robust cultural contrasts in gaze allocation. Taiwanese participants devoted the least attention to focal objects; one group from Turkey exhibited the most analytic pattern (and interesting “depth” effects when focusing more on closer objects), while the Czech and Ghana groups fell in between. Individual demographics explained, again, little of the variance.

Finally, **Study VIII** integrated self-construal assessment (see above) and task performance on hierarchical figures and map-symbol categorization (N = 103; Czech vs. Chinese respondents). No significant difference between samples was found in the hierarchical figures task. Mechanistically, multivariate map symbols demand binding across features and levels and invite either one-dimensional rule (analytic) or overall similarity rule (holistic) encoding strategies. The data supported expected group differences (Czech students categorized multivariate map symbols more analytically than continental Chinese/Taiwanese students)

and provided correlational links between style measures and task performance, but these links were modest.

5.2.2 Convergent validity: Correlations between measures of cognitive style

Only studies that included multiple methods of cognitive assessment are included in this section. In **Study IV** (hierarchical figures, embedded figures) cross-cultural differences shifted with tasks, therefore convergence across tasks was limited. Latent-profile explorations did not support a single “metastyle” that would capture individuals (or countries) on one analytic–holistic dimension, consistent with a view that analyticism-holism reflects a bundle of partially overlapping processes rather than a single trait. This weakens the expectation that any one behavioral task should strongly predict performance on another.

In **Study V** (hierarchical figures, 2D scenes) cross-method links were weak: the hierarchical-figures measure did **not** meaningfully track the eye-tracking indices (fixation count or dwell-time distribution). Put plainly, within the same people, the ET “object–background” pattern did not line up tightly with the hierarchical figures “global–local” pattern, again cautioning against treating analyticism-holism as a single latent continuum visible on all tasks.

Study VIII (hierarchical figures, multivariate maps). Two notable links emerged. First, global-local processing predicted map categorization in the expected direction (more local processing → more analytic categorization). Second, individualism–collectivism was a weak predictor of cognitive style, echoing our psychometric caution from Studies II–III. Together with IV and V, this points to selective convergence among behavioral measures, and only modest bridges between questionnaire constructs and perceptual performance.

5.3 Limitations

Although presented studies provide a new insight into the area of cross-cultural differences in perception and cognition, they are not without limitations. Across Studies IV–VIII, our **samples** were university students, with most cultural contrasts centered on Central Europe and East Asia (plus Ghana and Turkey in VI–VII). This limits generalizability and risks WEIRD over-reliance (Western, Educated, Industrialized, Rich, Democratic). As Henrich et al. (2010) argued, many well-known psychological effects vary across populations, so claims drawn from narrow samples should be tempered. The absence of a U.S. sample - the de facto “analytic” anchor in many East–West comparisons - further constrains external comparisons of the studies.

The studies deliberately spanned multiple **task families** (global–local hierarchical figures, embedded figures, free-viewing in 2D and immersive 3D, symbol categorization). Yet convergence across these indicators was modest (V, VIII), and latent profiles did not reveal a single “metastyle” (IV). This is a strength in that we can diagnose dissociations, but it

complicates construct coverage: any single task risks over-indexing one subprocess (e.g., attentional breadth vs. object–context binding).

Measurement constraints at the individual level. Studies II–III documented psychometric problems for self-construal/INDCOL instruments in Czechia and parts of the Western Balkans (suboptimal factor structures; weak invariance). These issues make individual-difference explanations precarious and likely contributed to weak self-report ↔ behavior links (VIII). More broadly, links between social orientation and cognition are often small and unstable across measures, even when each shows within-person stability (Na et al., 2020).

Setting and design considerations. Study IV blended lab and online data; while this boosted N and cultural reach, it introduced heterogeneous noise (e.g., display sizes, environments). Study V–VII used harmonized eye-tracking/VR protocols, but even here scene content and AOI segmentation decisions can subtly shape object–context metrics. More work with scene- and index-robustness checks (e.g., multiverse specifications) is warranted.

Inference constraints. Most designs are cross-sectional. Without longitudinal or intervention components, causal claims about predictors (e.g., social orientation, ecology) remain provisional. Finally, RT analyses can be sensitive to distributional assumptions and preprocessing; although IV followed current best practice, diffusion/accumulation modeling still requires caution in interpretation (e.g., separating boundary setting from drift).

5.4 Future research

Behavioral measures of self-construals. One problem identified during my research was a psychometric fragility of self-construal questionnaires in some contexts (II–III), the next step is to complement (or replace) self-reports with behavioral tasks that tap context sensitivity or social orientation directly. An interesting approach was adopted by Talhelm et al. (2018) in his study on how people were sitting and rearranging chairs in Starbucks in China. Development of similar behavioral measures of independence/interdependence usable in multiple countries might be promising for the future development of the field.

Combined emit-etic approach. I also perceive it as necessary to take several steps back. Continue using cross-culturally comparable tasks (etic) but co-develop emic materials (e.g., culturally familiar 2D/3D scenes; symbol sets; context cues) with local collaborators. This preserves comparability while ensuring local relevance and may reduce construct under-representation or bias in stimuli.

Fine-grained, within-country predictors. Rather than only country scores, leverage regional ecological indicators (e.g., subsistence history, mobility, tightness–looseness, relational mobility) to predict perceptual strategies. Prior work (Talhelm et al., 2018; Uskul et al., 2008)

shows that local ecologies (farming vs. fishing vs. herding; rice vs. wheat) covary with attention/holism; embedding similar contrasts within countries in Europe, Africa, and Asia could sharpen mechanism tests.

Longitudinal and intervention designs. Two promising routes: (a) repeated-measures cohorts across semesters or migration contexts to track whether A/H indices shift with social and learning environments; (b) targeted training or context manipulations (e.g., analytic vs. holistic task framing, attention-control training) to test short-term malleability and boundary conditions. This would help adjudicate trait-like vs. context-responsive components.

Convergence modeling. Adopt multitrait–multimethod (MTMM) designs and hierarchical latent models that explicitly partition common vs. method-specific variance across analytic/holistic tasks. For RT-based tasks, combine hierarchical evidence-accumulation models with cross-cultural random effects to separate speed–accuracy trade-offs from attentional selection.

5.5 Final conclusion

This thesis set out to ask a simple but stubbornly difficult question: when and why do cultures differ in perception and cognition - and when do they not? I approached the problem on two fronts. First, I examined the measurement scaffolding that makes cross-cultural claims credible (Study I; Studies II–III). Second, I tested for empirical differences across tasks that scale in complexity, from minimal perceptual discriminations (Study IV), through free viewing of complex 2D scenes (Studies V–VI) and immersive 3D environments (Study VII), to categorical decisions about multivariate map symbols (Study VIII). Three conclusions emerge.

1) Cultural differences are real but selective and task/index-dependent. Across eye-tracking in 2D and VR (Studies V–VII), I observed robust object–context allocation differences, with East Asian groups generally devoting relatively more attention to background than several Central European, Turkish, and Ghanaian samples. Yet these differences were metric-specific (e.g., dwell time vs. fixation count) and not universal across all contrasts. On minimal tasks (Study IV), cross-cultural variance was detectable but modest and context-sensitive; country rank orders were task-specific rather than a single analytic–holistic ladder. In symbol categorization (Study VIII), expected group tendencies appeared, but again with moderate effect sizes.

2) There is no single “metastyle.” Convergence across methods is limited. If analyticism–holism were a unitary trait, measures should hang together within individuals and countries. They did not. The hierarchical-figures indices did not strongly track object–background eye-tracking measures (Study V), and latent profiles failed to reveal a one-dimension solution (Study IV). Where convergence did appear (e.g., global–local predicting analytic symbol

categorization in Study VIII), it was selective rather than sweeping. The most defensible view is that “analytic/holistic” summarizes a bundle of partially overlapping processes (attentional breadth, object–context binding, rule use, tolerance for contradiction), which different tasks tap with different weights.

3) Popular predictors travel unevenly from theory to data. At the individual level, widely used self-construal/INDCOL scales showed problematic psychometrics in Czechia and parts of the Western Balkans (Studies II–III) and only weak links to behavioral outcomes (Study VIII). At the macro level, Hofstede/Schwartz scores were blunt instruments: occasionally associated with performance in Study IV, but inconsistent across outcomes and analysis choices. Together, these results argue for shifting emphasis toward behavioral and ecological predictors and task-based indices of social orientation that offer clearer mechanistic bridges to perception.

Thematically, these findings invite a calibration of the analytic–holistic framework. The theory remains useful as a map of tendencies, not a single compass. Cultural differences manifest most reliably when tasks recruit relations and context in overt attention (object–background trade-offs) or feature binding under ambiguity (symbol categorization). They attenuate when tasks reduce context demands or are dominated by low-level salience. Predictors that are too distant from perception (broad value indices, fragile self-reports) underperform; proximal, behavior-grounded predictors hold more promise.

Finally, this thesis underscores that progress in cultural cognitive science is cumulative when we: (a) treat measurement as theory-bearing; (b) triangulate across multiple tasks and settings; (c) embrace nulls and attenuations as boundary conditions; and (d) invest in behavioral, emic–etic measurement of the very predictors we hope to link to perception. I close with a constructive claim: culture shapes perception, but through multiple, partially independent routes. Mapping those routes - mechanistically, longitudinally, and across diverse ecologies—is the path forward. This thesis provides pieces of that map and a framework for adding the next ones.

Declaration on AI tools usage

ChatGPT (v5) was used in this thesis for the following purposes: finding literature (e.g. newly published studies on the topic), assistance in the thesis structuring and outlining, English proofreading. The author of the thesis is fully responsible for the thesis content.

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Appendices

Appendix Ia

Study I

[English translation]

Translation from the Czech original to English

Only for purposes of habilitation procedure of Ing. Mgr. Jiří Čeněk, Ph.D.

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Translation conducted by Ing. Mgr. Jiří Čeněk, Ph.D.

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The translation is identical to the original

Metodické studie

THE ADAPTATION AND EQUIVALENCE OF TEST METHODS: AN INSPIRATION FOR PSYCHOLOGICAL ASSESSMENT OF MINORITIES IN THE CZECH REPUBLIC

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ABSTRACT

The adaptation and equivalence of test methods: An inspiration for psychological assessment of minorities in the Czech Republic

J. Čeněk, T. Urbánek

This review is focused on the issues of equivalence of the test methods and their adaptation from one culture into another. The emphasis is placed on the identification of the reserves of Czech psychological assessment in the area of minorities testing, and on methodological procedures common in cross-cultural psychology, which can be used in the process of test adaptation, in order to achieve the best possible validity of the test for the target population. The beginning of the article is concerned with cultural universality of psychological constructs,

various types of test bias and test equivalence. Furthermore, specific types of test adaptations, which are needed in order to ensure a creation of culturally equivalent version of psychological test, are described in a step-by-step approach.

key words:

bias,
culture,
equivalenc,
psychological assessment,
test adaptation

INTRODUCTION

The state of Czech psychodiagnostics and its problems have been discussed in several texts, for example by Urbánek (2010a, 2010b, 2013). The main problems of Czech psychodiagnostics can be considered to be: a) underfunding of institutions engaged in diagnostics, which often cannot afford to purchase commercial diagnostic tools for their psychologists; b) insufficient financial resources and effort devoted to the standardization of original Czech and foreign methods, leading to the absence of certain crucial data (e.g., on validity or reliability) necessary for evaluating the applicability of a method in the Czech environment; or the related c) absence or obsolescence of norms; and d) insufficient training of psychologists in psychodiagnostics.

The aim of this contribution, however, is not to lament the state of Czech psychodiagnostics, but to draw attention to a somewhat neglected, yet related issue — the problem of psychological testing of minority populations in the Czech Republic. Although the general social atmosphere in the years following the so-called “refugee crisis” cannot be considered particularly open to anything foreign, it must be acknowledged that the population of the Czech Republic is not ethnically

and nationally homogeneous. Many foreign nationals and individuals identifying with other nationalities live here (Czech Statistical Office, 2014). Do we have instruments that allow for valid psychological testing of, for example, Slovak, Polish, Ukrainian, or Vietnamese nationals? And do we need them? It is possible that in many cases we do not.

The aim of this article is to introduce certain concepts and methods used in cross-cultural psychology that may serve as inspiration and can be applied in the development and adaptation of psychodiagnostic methods — whether for the Czech majority population or for Czech minorities. The article also proposes a set of procedures covering the entire process of test development or adaptation. Following these procedures increases the likelihood that the resulting method will be of high quality (valid and reliable) and suitable for the given population (e.g., a minority group). Given the absence of established Czech translations for some English technical terms, suggested Czech equivalents will be provided in the text, with the original English terms and possible synonyms noted in footnotes¹. Individual topics will be illustrated with examples from foreign research.

UNIVERSALITY OF CONCEPTS, TEST METHOD EQUIVALENCE AND TYPES OF BIAS

The first question to address is the very cultural universality of psychological phenomena — that is, to what extent psychological phenomena such as intelligence, self-concept, or aggression are consistent across cultures (or between majority and minority groups), and to what extent they differ. Three approaches to the study of cultures can be distinguished: the emic, the etic, and the combined approach. According to the emic approach, psychological phenomena are so different across cultures that they cannot be compared. Within this approach, individual cultures are studied in isolation, the formulation of concepts originates within those cultures, and there is no attempt to generalize conclusions. By contrast, research based on the etic approach views phenomena from an external perspective, assumes their universality, and usually compares multiple cultures with each other (Malhotra, Agarwal, & Peterson, 1996). Both approaches can be combined, resulting in the emic–etic approach, which assumes that some aspects of a psychological construct are culturally universal, while others are culture-specific. This combined approach is currently regarded as the most appropriate (Schaffer & Riordan, 2003).

Intelligence tests used in the Czech Republic — such as the Wechsler scales, the Structure of Intelligence Test (TSI), the Woodcock-Johnson Battery, or the Intelligence Structure Analysis (ISA) (Urbánek, 2010b) — were translated from English with the implicit assumption that the construct of intelligence and its structure are the same for Czechs and Americans. Consequently, the tests were considered usable after translation, the removal of problematic scales, modification of problematic items, and the creation of Czech norms. This logic of test adaptation corresponds to the etic approach. From a methodological point of view, however, the so-called pseudo-etic approach — in which emic instruments created in Anglo-Saxon countries are automatically assumed to be etic, culturally universal tools — is considered the most problematic (yet also the most frequently used; Watkins, 2010).

¹ The topic was also addressed by Anýžová (2013, 2014a, b) in her dissertation and related articles, in which she in some cases (particularly concerning issues of equivalence) offers a different translation of English terms.

The combined emic–etic approach was demonstrated during the development of the CPAI² personality questionnaire by Cheung (Cheung, van de Vijver, & Leong, 2011). The aim was to create a personality questionnaire capable of capturing both universal and culture-specific dimensions of personality in the Chinese population. The emic phase of research involved generating a set of Chinese personality characteristics from multiple sources: focus groups, street surveys, expert opinions, as well as descriptions of personality traits found in traditional and contemporary Chinese literature. Items derived from Western personality tests (such as the MMPI) were also included. The characteristics were sorted into preliminary personality scales and transformed into questionnaire items. Based on data collection and analysis, scales corresponding to four factors were created: social influence, dependability, accommodation, and interpersonal relatedness. In the etic phase of the research, the factor structure of the CPAI was compared with that of the NEO Five-Factor Inventory. While three of the CPAI factors loaded together with NEO scales and can be considered universal, the fourth factor, Interpersonal Relatedness, was specific to Chinese culture. Conversely, the Openness dimension of the NEO did not appear to be represented in Chinese culture.

As an example of an emic approach to the study of intelligence, one can mention Sternberg's (2004) work on practical intelligence. Sternberg conceptualizes practical intelligence as the ability of an individual to adapt to and thrive in their environment. He conducted a study in Usenge village in western Kenya, whose population consisted largely of farmers with little or no formal schooling. In the region, parasitic diseases were widespread, and inhabitants used traditional medicine to combat them. The researchers developed an "intelligence test" for local children, based on their knowledge of medicinal herbs and their appropriate use. Children with better knowledge of traditional medicine were considered more intelligent. Needless to say, the authors — as well as most readers of this article — would probably fail completely in such an "intelligence test."

If we, as psychologists, do not adopt a radically emic approach to cultural and ethnic research and instead assume that psychological phenomena are at least to some extent universal and comparable across cultures, we encounter the problem of equivalence³ and bias in psychological constructs and methods. Bias and equivalence can be seen as two sides of the same coin. Bias may be defined as a systematic measurement error or a systematic difference in scores between two or more populations (in terms of culture or ethnicity) that is not caused by real differences in the trait or ability being measured (van de Vijver & Tanzer, 2004). Equivalence, by contrast, is understood as the absence of bias. For example, suppose we administer an intelligence test to Czech and Vietnamese children living in the Czech Republic, and Czech children systematically achieve higher scores. If there is no reason to assume that Czech children are actually more intelligent than Czech Vietnamese children (which could be inferred, for instance, from school performance or from parallel administration of other intelligence tests), then we may conclude that the test is biased between these two groups, and is therefore not equivalent. Bias (non-equivalence) should be understood as a threat to the validity and reliability of the test and of any conclusions drawn from its results (Leung & van de Vijver, 2008).

² Chinese Personality Assessment Inventory

³ In English, two terms are used in this context: equivalence and invariance. Due to the rather infrequent use of the word invariance in Czech, both terms are translated as 'ekvivalence'.

In the past, as many as 50 definitions and types of equivalence have been identified (Davidov et al., 2014). One can, for example, encounter the basic distinction between linguistic, metric, functional, and conceptual equivalence (Ægisdóttir, Gerstein, & Çinarbacs, 2008; Leong, Leung, & Cheung, 2010), or the division into conceptual, functional, and instrument equivalence (Green & White, 1976). The most transparent classification, however, appears to be the division into: Construct equivalence (sometimes referred to as structural equivalence), Method equivalence, and Measurement equivalence (Byrne et al., 2009; Malhotra, Agarwal, & Peterson, 1996; van de Vijver & Tanzer, 2004). Construct and method equivalence can further be divided into subtypes or themes (see Fig. 1).

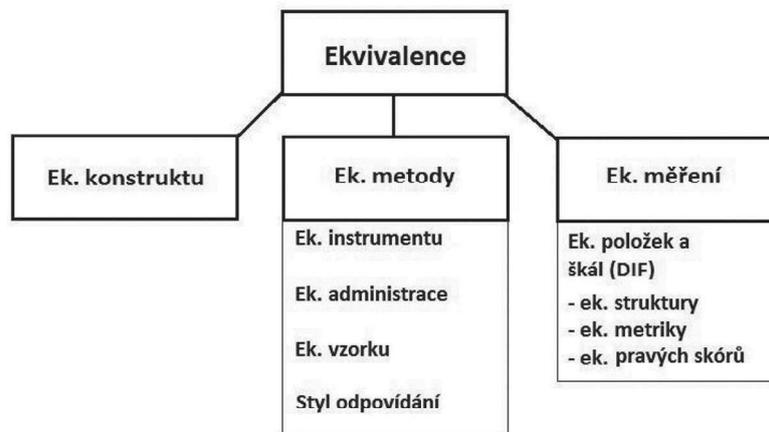


Fig. 1 Types of equivalence

Note: Figure not translated. Main three types of equivalence mentioned above, subtypes: instrument, administration, sample, response style (method), and equivalence of items and scales (DIF): structural, metric, true scores (see below)

Construct bias occurs when a construct is not identical across cultures (van de Vijver & Leung, 2001). An example can be the previously mentioned differences in the structure of personality traits in Chinese populations compared to the generally accepted five-factor model (Cheung, van de Vijver, & Leong, 2011). Other examples of construct non-equivalence include the different conceptions of intelligence in African and Asian cultures, where social intelligence is understood as part of general intelligence, or the conception of intelligence among the inhabitants of the Caroline Islands, where the ability to navigate using stars and ocean and wind currents is considered a mark of high intelligence (Čeněk, Smolík, & Vykoukalová, 2016). At this point, we may ask questions such as: Does the conception of intelligence and intelligent behavior among Roma from socially excluded localities correspond to the majority conception of intelligence? Are we able to reliably differentiate the level of cognitive abilities in this population using the methods available to us? Is the structure of personality traits among first- and second-generation Czech Vietnamese identical to the personality structure of the majority population? And so forth.⁴

Method bias can be caused by many factors arising from the process of

⁴ We are aware that, for example, intelligence is defined in practical applications by the majority, and is therefore a political decision; nevertheless, theoretical questions must not be left aside.

developing and administering a method. It may result from shortcomings in item format and wording, circumstances of administration, or characteristics of the research sample. Construct and method bias are subsequently reflected in the psychometric characteristics of test scales and items, which may exhibit signs of differential item functioning (DIF) across populations and other anomalies (van de Vijver & Poortinga, 2005).

ENSURING EQUIVALENCE IN THE PROCESS OF TEST ADAPTATION

It is necessary to clarify how the concept of “test adaptation” is understood within cross-cultural psychology, and what types of adaptation are distinguished. In general, test adaptation can be defined as modifications made to a test to allow its use in a different population. Van de Vijver and Tanzer (2004) describe three types of adaptation, differing in the degree and depth of the changes introduced: Application refers to the literal translation of a test from the source into the target language. The assumption is that the psychological construct does not differ across the cultures involved, and that translation produces items that are meaningful and comprehensible in the target language. At the other end of the spectrum is assembly, i.e., the development of an entirely new method. This option is used when construct equivalence cannot be assumed and the original test items would be incomprehensible or inappropriate in the target culture. Between these extremes lies adaptation in the narrower sense, where certain items are modified, removed, or added in order to maximize the validity of the instrument in the target population. Alternative and more detailed classifications of adaptation types have also been proposed (e.g., Malda et al., 2008).

In this section we will examine in more detail the causes of non-equivalence of test methods across cultural and ethnic groups, and the strategies that can help avoid errors in the adaptation process. The section is structured according to the logical sequence of steps in test development, roughly divided into: a) activities carried out before and during data collection (a priori procedures), and b) statistical analysis of data (a posteriori procedures; Malda et al., 2008).

Before data collection

The first comprehensive guidelines for test adaptation were developed at the initiative of the International Test Commission (ITC) in the second half of the 1990s (Hambleton, 1996; Hambleton & Patsula, 1999). These guidelines specify concrete procedures for test development and adaptation, administration, documentation, and subsequent statistical analysis and interpretation. The guidelines are regularly updated and refined.

The first question a test author must consider is the degree of construct equivalence, and therefore the type of adaptation that should be chosen (examples above). For statistical verification of construct equivalence, a set of techniques is available and will be discussed later in the text. Authors may also face situations where construct equivalence is uncertain, or where it is clear that equivalence does not exist. In such cases, the method of decentering can be applied (Green & White, 1976; Leong, Leung, & Cheung, 2010). Decentering involves experts from all relevant cultures jointly developing the instrument, so that the resulting test includes both culturally universal and culturally specific components of the construct. This approach prevents construct bias by ensuring that the test does not reflect solely the perspective of the majority culture (Leong, Leung, & Cheung, 2010). The disadvantage, however, is the increased time and financial cost of test development,

and the potential length of the instrument (if it must include all items relevant to all participating cultural groups). Other possible methods for assessing construct equivalence include focus groups and consultations with experts from the target cultural group (Davidov et al., 2014).

After choosing the type of adaptation, the next step is translation of the instrument into the target language, which falls under the category of instrument equivalence. The goal of translation (and adaptation as a whole) is to maximize both the linguistic and psychological similarity of the test in the two languages (van de Vijver & Poortinga, 2005). A necessary, though not sufficient, condition of quality translation is the high competence of translators. Using skilled translators and effective translation procedures increases the probability of linguistic similarity, though this does not automatically ensure psychological equivalence (van de Vijver & Poortinga, 2005).

When translating, authors should consider semantic similarity, clarity, readability, and style. They should not rely on a single translator; quality generally improves with the number of translators involved (Byrne et al., 2009). The back-translation method was long considered a “gold standard.” Here, the test is translated into the target language, then independently translated back into the source language. The two versions are compared, and non-equivalence is assumed when discrepancies occur. Recently, however, this method has been criticized (Behr, 2016), due to issues such as subjectivity in comparison, the influence of translators’ expertise, and the dependence on the quality of instructions provided to evaluators. Such factors may result in overlooked errors and thus non-equivalence.

Back-translation is not the only method. When linguistic and psychological differences between source and target cultures are large (e.g., translating a Czech test for first-generation Czech Vietnamese into Vietnamese), back-translation may be insufficient to guarantee equivalence (Green & White, 1976). Alternatives include parallel translation, where several independent translations are compared; or the committee approach, where a panel of experts evaluates and revises translations until consensus is reached (Watkins, 2010). Decentering (see above) can also be seen as a translation method, since both source and target versions are treated as equally important, and both can be modified to maximize equivalence (Ægisdóttir, Gerstein, & Çinarbacs, 2008). These methods may also be combined.

Practical linguistic principles for test development and translation include: a) using short and simple sentences, b) using active voice, c) repeating nouns rather than pronouns, d) avoiding metaphors, e) avoiding vague words, f) avoiding sentences with more than one verb, g) preferring concrete over abstract concepts (Malhotra, Agarwal, & Peterson, 1996), h) avoiding slang and idioms, and i) avoiding expressions and topics that may be inappropriate or offensive for the cultural group (ITC, 2017).

After translation (and adaptation of pictorial material, if used), a pilot test (pretest) should follow. This step is often neglected by test developers, yet it can be a source of non-equivalence and unfairness to particular cultural groups (ITC, 2017; Malda et al., 2008). Pretesting should ideally be repeated until all linguistically and psychologically non-equivalent items are eliminated (Ægisdóttir, Gerstein, & Çinarbacs, 2008).

In considering instrument equivalence, further aspects beyond translation should be evaluated: Are all test versions written in the same font? Are instructions identical? Are illustrations comprehensible to the target population? Are response formats clear to all groups? Do some groups have difficulties with certain item or response formats (ITC, 2017)?

Second of the topics that can be included in method equivalence is equivalence of administration. When testing multiple cultural groups, the goal is to minimize the influence of intervening variables caused by differences in administration, just as in repeated administrations within a single cultural group. Before test administration, it is advisable (ITC, 2017) to prepare a detailed manual, train administrators, verify their ability to follow the manual, and ensure the test is administered under comparable conditions (e.g., time of day, lighting, room temperature). Administering tests to different cultural groups, however, brings additional demands on the administrator, their interaction with respondents, and control of the testing situation.

If the administrator is from a different culture than the respondent, some degree of reactivity to the administrator and the testing situation can be expected. Respondents interpret the testing situation subjectively and may try to answer in line with what they think the administrator expects (Leung & van de Vijver, 2008). They may consciously minimize cultural differences, or exaggerate them to emphasize their ethnic identity (Leong, Leung, & Cheung, 2010). Their willingness to disclose personal information (e.g., in personality questionnaires) may vary depending on whether the administrator belongs to their own or a foreign culture. Van de Vijver and Tanzer (2004) describe the interviewer effect, in which the mere presence of an administrator from another culture influences respondents' answers. The most appropriate and bias-resistant form of test administration is when both administrator and respondents belong to the same ethnic group (Malhotra, Agarwal, & Peterson, 1996).

The relationship between administrator and respondent can also cause method bias when respondents feel uncomfortable. This may stem from perceived differences in social status (Schaffer & Riordan, 2003), or from mismatches in gender in sensitive topics or cultures (e.g., African or Middle Eastern cultures; Malhotra, Agarwal, & Peterson, 1996).

The third topic related to the method equivalence is (research) sample equivalence. Sample bias occurs when differences in test performance are not due to differences in the measured trait, but to systematic differences between groups (Leung & van de Vijver, 2008). For example, imagine testing intelligence among university students in the Czech Republic and in Bangladesh. If one group systematically outperforms the other, and assuming the test was well adapted and administered, is this a true difference in intelligence? Or could it reflect sampling differences? For instance, if only the top 5% of Bangladeshi students are admitted to university, they will logically outperform Czech university students, for whom access to tertiary education is less selective.

In cross-cultural and minority research, sampling methods themselves can be problematic. Probability sampling may be unrealistic for hard-to-reach groups (such as Czech minorities). Non-probability methods like quota or snowball sampling are often used. In extreme cases, different methods may be applied to subgroups (e.g., probability sampling for the majority, quota sampling for minorities; Malhotra, Agarwal, & Peterson, 1996).

Even when comparing large, demographically matched samples, perfect comparability across cultures is difficult to achieve. Nonetheless, matching on variables such as gender, age, socioeconomic status, and size of settlement is recommended (Green & White, 1976). For cognitive tests, Van de Vijver and Tanzer (2004) additionally suggest monitoring variables such as education system (e.g., school quality), testing experience, and respondent motivation. These variables should

be statistically controlled (covaried) in later analyses to reveal their influence on test performance (Schaffer & Riordan, 2003).

The last topic traditionally included under method equivalence is the issue of so-called response styles (He & Van de Vijver, 2013). These are usually diagnosed only at the stage of statistical data analysis.

An excellent example of the application of a priori procedures in the adaptation of a cognitive test is provided by a study in which the authors adapted the Kaufman Assessment Battery for Children (KABC-II; see Malda et al., 2008). The core of their adaptation procedure was an iterative process of qualitative evaluation and subsequent modification of the test, with the aim of maximizing children's understanding of the test and its individual items.

The KABC-II (Kaufman & Kaufman, 2004) is originally an American test of cognitive abilities intended for children and adolescents aged 3 to 18 years. It was adapted for children from lower socioeconomic backgrounds living in the South Indian city of Bangalore, whose mother tongue is Kannada (Malda et al., 2008).

In the first phase, the authors of the adaptation (Malda et al., 2008) conducted field research — visits to schools and homes of children, and interviews with their teachers and parents — in order to assess the level of cognitive stimulation and subsequently determine the type of adaptation required. They examined, for example, the number and types of toys children played with, school textbooks and other learning materials, teaching styles in local schools, and whether families owned a television. In the second phase, the actual iterative a priori adaptation procedure was carried out, during which the authors, in cooperation with local experts, translated, piloted, and modified the tests. To illustrate the demands of such a task, the second phase of adaptation lasted eight (!) months.

The initial translation was carried out by four psychologists fluent in both English and Kannada. The translation was then back-translated by another translator, piloted several times, and repeatedly modified. Pilot testing was administered non-standardly (i.e., not according to the manual instructions). The goal was to identify the ways in which children reasoned about the test questions and answers. To achieve this, the cognitive interviewing technique (Willis, 2005) was used. For each item, the child was asked to repeat the instructions, their understanding was verified, they were then asked to think aloud about the possible answers, and finally to choose what they considered the correct one.

Depending on their nature, the subtests required different types of adaptation (Malda et al., 2008): 1) adaptation motivated by theory, 2) adaptation motivated by differences in knowledge, and 3) a combination of both types. The subtests Digit Span (short-term memory) and Atlantis (long-term memory) were adapted based on theoretical assumptions underlying their design. For Digit Span, the crucial issue was that the number of units storable in short-term memory depends on their phonological length (see the phonological loop model; Baddeley, Thomson, & Buchanan, 1975). It was therefore essential to keep syllable length constant across digits to be memorized. Since the digits 2 and 9 are trisyllabic in Kannada, their use in the subtest was restricted. In Atlantis (learning nonsense words paired with pictures and recalling them), the problem was the difference in phonological structures of the two languages — children had difficulty distinguishing the phonological structures of English nonsense words. It was therefore necessary to create nonsense words with Kannada phonology (Malda et al., 2008).

Knowledge-difference based adaptations were carried out for several subtests aimed at measuring visual abilities and fluid intelligence. To illustrate the most interesting examples: Kannada children are not accustomed to working under time pressure (Malda et al., 2008). Therefore, time limits for scoring correct responses were extended in some subtests on the basis of pilot testing. The Story Completion subtest (fluid intelligence) included items describing life situations common in American populations (inflating balloons, birthday celebrations, blowing one's nose into a handkerchief), but unfamiliar to Kannada children. This subtest was therefore completely replaced by an analogue of the picture sequencing task from the WISC-R battery. The pictures were redrawn by a local artist to eliminate possible sources of misunderstanding. For example, in one item, a thief climbs through a house window and is later caught by the police. In the original version, children did not recognize the clue indicating a thief (a mask over the eyes) and did not recognize the window (vertically opening sash window). In the adapted version, the thief was given a more distinctively 'Indian' appearance, and the window was depicted as opening horizontally.

The above examples of a priori adaptation procedures demonstrate the difficulties faced by test developers adapting instruments for other cultural or ethnic groups. They also show that even items from relatively simple nonverbal tests may not carry the same meaning across populations, may not be equally understandable or familiar, and in other words may not be culture-free.

Statistical analysis

After conducting all qualitative procedures for test adaptation and data collection, researchers typically examine the psychometric evidence for validity and reliability of the instrument (see Urbánek, Denglerová, & Širůček, 2011). In other words, they ask whether the test measures what it is intended to measure, and how precisely. Standard analyses include examining the factor structure of scales using exploratory factor analysis (EFA), or, preferably, confirmatory factor analysis (CFA) when hypothesized structures are available. Reliability is assessed in terms of stability over time (test-retest) or internal consistency (parallel forms, split-half, Cronbach's alpha). Further, sources of validity are tested, such as concurrent and discriminant validity with respect to other methods.

These procedures are already routinely used in the Czech Republic. However, in the context of adapting tests across cultures and ethnic groups, they are not considered sufficient. Leading journals now require the use of additional psychometric techniques to verify validity and reliability (Leung & van de Vijver, 2008). As discussed earlier, various sources of construct and method non-equivalence can manifest as measurement non-equivalence — i.e., differential item functioning (DIF) across populations. Methodological literature in cross-cultural psychology offers various typologies of DIF (see van de Vijver & Tanzer, 2004; van de Vijver & Poortinga, 2005). We believe that the most understandable classification distinguishes three types of measurement equivalence: a) structural equivalence, b) metric equivalence, c) true score equivalence.⁵ These

⁵ Compare with Anžžová (2013, 2014b), who uses slightly different terminology, but whose explanation may nevertheless be useful for readers of this article, as it is accompanied by a number of illustrative diagrams. In her empirical study on the statistical equivalence of Schwartz's Value Scale (2014a), she further demonstrates procedures for calculating equivalence in self-report scales.

three types of equivalence have a hierarchical structure - structural equivalence can be considered to be the lowest type and true score equivalence the highest type. Without establishing (at least partial) the lower type of equivalence, the higher type cannot be established (Davidov et al., 2014).⁶

Structural equivalence addresses whether the construct has the same structure across cultural groups. It can be seen as construct equivalence operationalized within a specific test — the manifestation of construct equivalence in data (van de Vijver & Poortinga, 2005). Statistically, this is typically analyzed using EFA or, preferably, CFA. Structural equivalence is evaluated by comparing the similarity of factor loading patterns (positive, zero, negative) across cultural groups.⁷ In EFA, the Tucker's phi coefficient is commonly used to measure the congruence of factor loading matrices (van de Vijver & Leung, 2001). For the calculation of the subsequent, higher types of equivalence, however, EFA is no longer considered an appropriate method; instead, CFA and multi-group structural equation models (MGSEM) are predominantly used. The statistical stability of these techniques, however, may — depending on the number of variables, the number of factors, and the strength of the loadings (Wolf et al., 2013) — place high demands on the size of the research sample (Cheung & Au, 2005).

A higher level of equivalence, metric equivalence, evaluates whether a latent variable is assessed across groups on the same scale. Once this level of equivalence is achieved, it becomes possible to meaningfully compare the relationships between the latent construct and other variables across two or more groups (using regression coefficients). Metric equivalence is achieved when all groups under comparison have similar factor loading values (Davidov et al., 2012).

Even after achieving lower levels of equivalence, it is not possible to meaningfully compare mean levels of the measured trait across populations. This becomes possible only after reaching the highest level of equivalence — scalar (true score) equivalence (Davidov et al., 2012). In other words, even though a method may capture the same construct across cultures or ethnic groups (structural equivalence), and on the same scale (metric equivalence), it is not guaranteed that the method does not systematically overestimate or underestimate the construct in one of the groups (non-equivalence of true scores). In such cases, observed differences in scores may be due to differential item functioning (DIF) rather than genuine differences in latent scores (Steenkamp & Baumgartner, 1998). In assessing this form of equivalence, regression intercepts of individual items are also compared across groups (Davidov et al., 2012).

In intercultural empirical studies, achieving full metric and scalar equivalence often proves to be an unrealistic goal (see, e.g., Anýžová, 2014a; Lilleoja et al., 2016; Nye et al., 2008). In such cases, researchers aim to achieve at least partial equivalence, which requires equivalence in at least two items of the given scale (Steenkamp & Baumgartner, 1998). Other strategies for dealing with non-equivalence have been suggested by Davidov (see Davidov et al., 2014), including: (a) identifying subsamples across which equivalence is achieved, (b)

⁶ Provides an overview of methods for testing equivalence, including modern methods such as Bayesian Structural Equation Modeling (BSEM) and approaches based on Item Response Theory. An overview of software applicable to these types of tests is given, for example, by Van De Schoot (Van De Schoot et al., 2015).

⁷ For details on calculations of the individual types of equivalence, see Davidov et al. (2012) or Steenkamp & Baumgartner (1998). For further information on recommended values of individual fit indices in CFA and structural models, see Abubakar et al. (2015).

removing non-equivalent items, or (c) explaining sources of non-equivalence. The latter involves a shift in logic, where non-equivalence is viewed as a useful source of information about intergroup differences (so-called MIMIC models). According to more recent perspectives (Byrne & van de Vijver, 2017), in some cases — particularly when a large number of groups are compared — achieving higher levels of equivalence through classical MGSEM approaches is practically impossible, and the use of less restrictive statistical models of approximate equivalence (ESEM, BSEM) is recommended.

The last topic to be briefly addressed here is that of response styles and response bias. Even if measurement equivalence is confirmed for a test, we cannot be certain that differences in group means or other statistics are actually caused by differences in the latent trait, rather than by differences in response style (Davidov et al., 2012).

Response style is classified as a form of method bias and is defined as the tendency of respondents to answer items independently of their content (Peterson, Rhi-Perez, & Albaum, 2014). Response style is most evident in personality, value, and attitude questionnaires, and similar instruments using subjective Likert-type self-report scales. The most commonly distinguished response styles are (He & Van de Vijver, 2013): a) acquiescence bias (yea-saying), b) socially desirable responding, c) extreme responding, and d) midpoint responding. The presence of response bias can be tested with appropriate methods, such as the parallel administration of a social desirability scale, or through indices specific to each type of bias.

It is assumed that the tendency to choose different points on the scale is influenced by cultural factors such as individualism/collectivism, the values of other cultural dimensions, the degree of conformity in society, socioeconomic status, and so forth (Johnson et al., 2005). If members of Czech minorities differ from the majority in some of these factors, they can also be expected to differ in their response styles.

CONCLUSION

This article has addressed the question of whether (and how) members of national minorities should be tested using methods originally developed for the majority population. Insights from cross-cultural psychology provide a conceptual framework for considering the possibilities and conditions under which universal psychological traits may exist. Research and experience with adapting instruments from one cultural environment to another clearly show that various forms or levels of universality (and thus equivalence of measurement instruments) cannot simply be assumed — they must be empirically verified. If some assumptions do not hold, the process of test adaptation must be adjusted accordingly.

These issues are closely related to the fairness of test use with minority populations, which leads us directly to questions of the validity of such assessments. Since validity depends on the quality of standardization (including norm development), the procedures discussed in this article become crucial. Without careful consideration of the many aspects of (non-)equivalence when applying tests to culturally diverse groups, test adaptation may result in invalid tools. In turn, such invalidity can produce distorted findings in research applications, and in practical applications may even lead to professional errors.

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SUMMARY

This article deals with the issue of equivalence of test methods and the possibilities of their adaptation from one culture to another. Emphasis is placed on identifying the shortcomings of Czech psychodiagnostics in the field of minority testing, and on methodological procedures common in cross-cultural psychology that can be employed in the process of test adaptation in order to achieve the best possible validity of the resulting test for the target population. The introduction addresses the cultural universality of psychological constructs, various types of cultural bias, and test equivalence. The article then discusses specific types of test adaptations and the individual steps and procedures necessary to create a culturally equivalent version of a psychological test.

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Appendix Ib

Study I

[Czech original]

Metodické studie

ADAPTACE A EKVIVALENCE TESTOVÝCH METOD: INSPIRACE PRO PSYCHOLOGICKÉ TESTOVÁNÍ MINORIT V ČR

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ABSTRACT

The adaptation and equivalence of test methods: An inspiration for psychological assessment of minorities in the Czech Republic

J. Čeněk, T. Urbánek

This review is focused on the issues of equivalence of the test methods and their adaptation from one culture into another. The emphasis is placed on the identification of the reserves of Czech psychological assessment in the area of minorities testing, and on methodological procedures common in cross-cultural psychology, which can be used in the process of test adaptation, in order to achieve the best possible validity of the test for the target population. The beginning of the article is concerned with cultural universality of psychological constructs,

various types of test bias and test equivalence. Furthermore, specific types of test adaptations, which are needed in order to ensure a creation of culturally equivalent version of psychological test, are described in a step-by-step approach.

key words:

bias,
culture,
equivalence,
psychological assessment,
test adaptation

klíčová slova:

zkreslení,
kultura,
ekvivalence,
psychodiagnostika,
adaptace testu

ÚVOD

O stavu české psychodiagnostiky a o jejích problémech referuje v několika svých textech například Urbánek (2010a, b, 2013). Za hlavní problémy české psychodiagnostiky lze považovat: a) podfinancovanost institucí zabývajících se diagnostikou, kdy si tyto instituce často nemohou dovolit nakupovat pro své psychology komerční diagnostické nástroje; b) nedostatečné finance a úsilí věnované standardizaci původních českých a zahraničních metod, které vedou k absenci některých údajů (např. o validitě či reliabilitě) důležitých k zhodnocení použitelnosti této metody v českém prostředí; či s předchozím bodem související c) absenci či zastaralost norem, d) nedostatečné vzdělání psychologů v oblasti psychodiagnostiky.

Cílem tohoto příspěvku ovšem není hořekovat nad stavem české psychodiagnostiky, ale upozornit na poněkud opomíjený problém s tématem související – problém

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s psychologickým testováním minoritních populací v ČR. Přestože obecnou společenskou atmosféru v letech po takzvané „uprchlické krizi“ nelze považovat za příliš otevřenou čemukoliv cizímu, je třeba si přiznat, že obyvatelstvo v ČR není etnicky a národnostně homogenní, ale že zde žije mnoho cizích státních příslušníků či osob hlásících se k jiné národnosti (ČSÚ, 2014). Máme k dispozici nástroje umožňující validní psychologické testování příslušníků například slovenské, polské, ukrajinské či vietnamské národnosti? A potřebujeme je? Je možné, že v mnoha případech nikoliv.

Cílem tohoto článku je představit některé koncepty a metody využívané v oblasti interkulturní psychologie, kterými je možné se inspirovat a které je možné použít při tvorbě a adaptaci psychodiagnostických metod, ať už pro českou majoritní populaci, či pro české menšiny. Bude zde také navržen soubor postupů týkajících se celého procesu tvorby či adaptace testu, při jejichž dodržení je možno zvýšit pravděpodobnost toho, že výsledná metoda bude kvalitní (validní a reliabilní) a také vhodná pro danou populaci (například minoritu). Vzhledem k absenci ustáleného překladu některých anglických odborných termínů budou v textu navrženy jejich české překlady a v poznámkách pod čarou bude uvedeno jejich anglické znění a případná synonyma¹. Jednotlivá témata budou ilustrována pomocí příkladů ze zahraničních výzkumů.

UNIVERZALITA KONCEPTŮ, EKVIVALENCE TESTOVÝCH METOD A TYPY ZKRESLENÍ

První otázkou, kterou je potřeba se zabývat, je samotná kulturní univerzalita psychologických fenoménů, tedy to, do jaké míry se psychologické fenomény, jako je například inteligence, sebepojetí či agrese, mezi kulturami (či majoritou a minoritou) shodují nebo odlišují. Lze rozlišit celkem tři přístupy ke studiu kultur: emický, etický a kombinovaný. Podle emického přístupu jsou psychologické fenomény napříč kulturami tak odlišné, že je nelze porovnávat. V rámci tohoto přístupu jsou jednotlivé kultury studovány izolovaně, formulace jednotlivých konceptů vycházejí zevnitř těchto kultur a rezignuje se na jakoukoliv snahu zobecňovat závěry emických výzkumů. Naopak výzkumy vycházející z etického přístupu na daný fenomén nahlíží z vnějšku, považují ho za univerzální a zpravidla porovnávají více kultur mezi sebou (Malhotra, Agarwal, Peterson, 1996). Oba přístupy lze kombinovat a tento emicko-etický přístup, podle kterého jsou některé aspekty psychologického konstruktů kulturně univerzální a jiné jsou kulturně specifické, je v současné době považován za přístup nejnvhodnější (Schaffer, Riordan, 2003).

V ČR používané testy inteligence, jako jsou například Wechslerovy testy, Test struktury inteligence (TSI), Woodcockova-Johnsonova baterie nebo Analýza struktury inteligence (ISA) (Urbánek, 2010b), byly přeloženy z angličtiny s implicitním předpokladem, že inteligence a její struktura se u Čechů a Američanů neliší, a že testy je tedy možno po překladu, vyřazení problematických škál, úpravě problematických položek a vytvoření českých norem bez problémů použít i u české populace. Tato logika tvorby (adaptace) testu odpovídá etickému přístupu. Z metodologického úhlu pohledu lze za nejproblematictější (a také nejčastěji využívaný) považovat takzvaný pseudo-etický přístup, při kterém jsou emické nástroje vytvořené nejčastěji v anglosaských zemích považovány automaticky za nástroje etické, kulturně univerzální (Watkins, 2010).

¹ Tématem se ve své dizertační práci a v souvisejících článcích zabývala také Anýžová (2013, 2014a, b), která v některých případech (zejména týkající se problematiky ekvivalence) nabízí odlišný překlad anglických termínů.

Kombinovaný emicko-etický přístup demonstroval během procesu tvorby osobnostního dotazníku CPAI² Cheung (Cheung, van de Vijver, Leong, 2011). Ambicí bylo vytvořit osobnostní dotazník, který by byl schopen zjišťovat jak univerzální, tak kulturně specifické dimenze osobnosti u čínské populace. Emická fáze výzkumu spočívala v generování souboru popisů čínských osobnostních charakteristik, a to z více zdrojů. Bylo využito metody ohniskových skupin, anket na ulicích, expertních názorů, začleněny byly i popisy osobnostních charakteristik vyskytující se v tradiční lidové i soudobé čínské literatuře. Zahrnuty byly také položky tvořené na základě západních testů osobnosti (MMPI). Osobnostní charakteristiky byly následně rozříděny do předběžných osobnostních škál a transformovány na dotazníkové položky. Na základě sběru a analýzy dat byly vytvořeny osobnostní škály sytící čtyři faktory – sociální vliv, spolehlivost, přizpůsobivost a vztahování se k druhým. V etické fázi výzkumu byla porovnána faktorová struktura CPAI a pětifaktorového osobnostního dotazníku NEO. Zatímco první ze tří faktorů CPAI sytily faktory společně se škálami dotazníku NEO a lze je považovat za univerzální, faktor čtvrtý Vztahování se k druhým je specifický pro čínskou kulturu. Naopak dimenze otevřenosti NEO se nezdá být v čínské kultuře zastoupena.

Jako příklad emického přístupu ke studiu inteligence lze uvést Sternbergovu (2004) práci, která vychází z jeho pojetí praktické inteligence. Sternberg chápe praktickou inteligenci (či praktickou složku inteligence) jako schopnost jedince adaptovat se na prostředí a prospívat v něm. Sternberg provedl studii ve vesnici Usenge v západní Keni. Místní populace je tvořena převážně farmáři bez formálního vzdělání či pouze s několika roky základní školní docházky. V oblasti je rozšířené množství parazitických onemocnění a obyvatelé proti nim užívají prostředky přírodní medicíny. Autoři studie vytvořili test „inteligence“ pro místní děti, který je založený na znalosti léčebných bylinek a jejich správného používání. Za inteligentnější jsou považovány ty z dětí, které mají lepší znalosti přírodní medicíny. Není třeba poznamenávat, že autoři i většina čtenářů tohoto článku by v takovémto testu inteligence pravděpodobně zcela propadli.

Pokud jako psychologové nepřijmeme radikálně emický přístup k výzkumu kultur a etnik a připustíme, že psychologické fenomény jsou alespoň do jisté míry univerzální a je možno je u jedinců z různých kultur porovnávat, narazíme na problematiku psychologické podobnosti psychologických konstruktů a metod, jinými slovy na problematiku ekvivalence³ a zkreslení (*bias*). Zkreslení a ekvivalenci lze chápat jako dvě strany téže mince. Zkreslení lze definovat jako systematickou chybu měření, či systematický rozdíl ve skórech dvou a více populací (ve smyslu kultur nebo etnik), která není způsobena reálnými rozdíly v daném rysu či schopnosti (van de Vijver, Tanzer, 2004). Ekvivalence je pak chápána jako absence zkreslení. Řekněme například, že administrujeme test inteligence u dětí Čechů a českých Vietnamců a Češi v tomto testu systematicky dosahují lepších skóre. Pokud není důvod se domnívat, že skupina českých dětí není ve skutečnosti inteligentnější než skupina dětí českých Vietnamců (na což lze usuzovat například z analýzy studijních průměrů či z paralelní administrace dalších metod k měření inteligence), lze usoudit, že v testu mezi těmito dvěma skupinami dochází ke zkreslení, test tedy není pro obě skupiny ekvivalentní. Zkreslení (neekvivalenci) lze chápat jako ohrožení validity a reliability testu a závěrů, které na základě jeho analýzy formulujeme (Leung, van de Vijver, 2008).

² Chinese Personality Assessment Inventory

³ V angličtině jsou v tomto kontextu používány dva termíny: „*equivalence*“ a „*invariance*“. Z důvodu nepřilíživého používání slova „*invariance*“ v češtině jsou oba dva termíny překládány jako „*ekvivalence*“.

V minulosti bylo identifikováno na 50 definic a typů ekvivalence (Davidov et al., 2014). Lze se například setkat se základním rozlišením na lingvistickou, metrickou, funkční a konceptuální ekvivalenci (Ægisdóttir, Gerstein, Çinarbacs, 2008; Leong, Leung, Cheung, 2010), či na konceptuální a funkční ekvivalenci a ekvivalenci nástroje (Green, White, 1976). Za nejpřehlednější však autoři tohoto textu považují členění ekvivalence na: 1) ekvivalenci konstruktů (někdy také ekvivalence struktury), 2) ekvivalenci metody, a 3) ekvivalenci měření (Byrne et al., 2009; Malhotra, Agarwal, Peterson, 1996; van de Vijver, Tanzer, 2004). Základní typy ekvivalence lze dále dělit do dalších podtypů, resp. témat, jichž se týkají (obr. 1).



Obr. 1 Typy ekvivalence

Ke zkreslení na úrovni konstruktů dochází v případě, že konstrukt není identický napříč kulturami (van de Vijver, Leung, 2001). Jako příklad lze použít dříve zmíněné odlišnosti ve struktuře osobnostních rysů u Číňanů oproti všeobecně přijímanému pětifaktorovému modelu (Cheung, van de Vijver, Leong, 2011). Mezi dalšími příklady neekvivalence konstruktů lze uvést odlišné pojetí inteligence u afrických a asijských kultur, kde je sociální inteligence chápána jako součást inteligence obecné, či pojetí inteligence u obyvatel Karolínských ostrovů, u kterých je jako vysoce inteligentní chápána schopnost navigovat za pomoci hvězd a mořských a větrných proudů (Čeněk, Smolík, Vykoukalová, 2016). Na tomto místě si můžeme klást otázky typu: Souhlasí pojetí inteligence a inteligentního chování u Romů z vyloučených lokalit s majoritním pojetím inteligence? Jsme schopni u této populace dostupnými metodami spolehlivě diferencovat úroveň rozumových schopností? Je struktura osobnostních rysů českých Vietnamců první a druhé generace shodná s osobnostní strukturou majority? a podobně⁴.

Zkreslení na úrovni metody může být způsobeno mnoha faktory vyplývajícími z procesu tvorby a administrace metody. Může být způsobeno nedostatky ve formátu a formulaci položek, okolnostmi administrace či charakteristikami výzkumného vzorku. Zkreslení na úrovni konstruktů a metody se následně promítají do psychometrických charakteristik škál a položek testu, které mohou vykazovat známky odlišného fungování (*differential item functioning*, DIF) pro různé populace a další anomálie (van de Vijver, Poortinga, 2005).

⁴ Uvědomujeme si, že např. inteligenci v praktických aplikacích definuje majorita a jde tedy o politické rozhodnutí, přesto ale teoretické otázky nesmějí zůstat stranou.

ZAJIŠTĚNÍ EKVIVALENCE V PROCESU ADAPTACE TESTU

Je nutné vysvětlit, jak je v rámci interkulturní psychologie chápán pojem „adaptace testu“ a jaké jsou její typy. Obecně je možné pojem adaptace testu chápat jako změny v testu, které jsou prováděny proto, aby bylo možné použití testu v jiné populaci. Van de Vijver a Tanzer (2004) definují tři typy adaptace, které se mezi sebou liší množstvím a hloubkou provedených změn. V případě aplikace (*application*) se jedná o doslovný překlad testu z původního do cílového jazyka. Předpokládáme, že psychologický konstrukt se u daných kultur neliší a že překladem vzniknou položky, které jsou smysluplné a pochopitelné i v cílovém jazyce. Na druhém konci spektra se nachází tvorba zcela nové metody (*assembly*), ke které se uchylujeme v případě, že nelze předpokládat ekvivalenci konstruktů a že obsah položek by byl v cílové kultuře nepochopitelný či nevhodný. Mezi těmito dvěma póly se nachází adaptace (*adaptation*), při které upravujeme obsah některých položek, nebo odstraňujeme či přidáváme některé položky s cílem maximalizovat validitu instrumentu u cílové populace. Odlišné a podrobnější členění typů adaptace testu nabízí například Malda (viz Malda et al., 2008).

V této části se budeme dále podrobněji zabývat jednotlivými příčinami neekvivalence testových metod u příslušníků odlišných kultur či etnik a také způsoby, pomocí kterých je možné vyvarovat se zbytečných chyb v procesu adaptace. Oddíl je strukturován s ohledem na logický sled kroků v procesu tvorby testu a lze ji zhruba rozdělit na dvě části: a) činnosti prováděné před sběrem a během sběru dat (*a priori procedures*), b) statistická analýza dat (*a posteriori procedures*; Malda et al., 2008).

Fáze před sběrem dat

První komplexní návody, jak postupovat během procesu adaptace testu, byly vytvořeny z popudu Mezinárodní komise pro testování (International Test Commission, ITC) v druhé polovině 90. let (Hambleton, 1996; Hambleton, Patsula, 1999). Směrnice stanovují konkrétní postupy tvorby a adaptace metody, postupu administrace, dokumentace a následné statistické analýzy a interpretace dat. Původní směrnice jsou pravidelně upravovány a dopracovávány.

První otázkou, kterou by měl autor metody zvážit, je míra ekvivalence měřeného konstruktů a tedy i typ adaptace, který by měl zvolit (příklady výše). Pro statistické ověření ekvivalence konstruktů existuje soubor technik, které budou rozebrány dále v textu. Je také možné, že se autor metody dostane do situace, kdy si nebude jistý ekvivalencí konstruktů v obou kulturách, či si dokonce bude jistý, že konstruktů ekvivalentní nejsou. V tomto případě je možné využití metody decentrace (*decentering*; Green, White, 1976; Leong, Leung, Cheung, 2010). Decentrace spočívá v tom, že experti ze všech kultur, pro které je test určen, vyvíjejí metodu společně a metoda následně obsahuje jak kulturně univerzální, tak kulturně specifické složky daného konstruktů. Tento přístup v případě testů vyvíjených pro etnické menšiny má výhodu v tom, že brání zkruslení na úrovni konstruktů v tom smyslu, že konstrukt odráží primárně pohled majority (Leong, Leung, Cheung, 2010). Nevýhodou naopak bývá zvýšená časová a finanční náročnost tvorby testu a délka nástroje (zda obsahuje všechny položky relevantní pro všechny zúčastněné kulturní skupiny). Dalšími možnými metodami hodnocení ekvivalence konstruktů jsou ohniskové skupiny a konzultace s experty z dané kulturní skupiny (Davidov et al., 2014).

Na volbu typu adaptace navazuje proces překladu metody do cílového jazyka řazeného do kategorie ekvivalence instrumentu. Cílem překladu (a adaptace jako celku) je maximalizace lingvistické a psychologické podobnosti testu v obou jazycích (van de Vijver, Poortinga, 2005). Nutným, ale ne dostačujícím předpokladem kvalitního

překlady metody je vysoká kvalifikovanost překladatelů z původního do cílového jazyka. Využitím kvalitních překladatelů a metod překlady zvýšíme pravděpodobnost lingvistické podobnosti testu, která ovšem nezaručuje i podobnost psychologickou (van de Vijver, Poortinga, 2005).

Autor metody by měl zvažovat takové faktory, jako je sémantická podobnost obou verzí, pochopitelnost textu, jeho čtivost a styl. Autoři by se neměli spoléhat pouze na jednoho překladatele. Kvalita metody se zpravidla zvyšuje s rostoucím počtem překladatelů, kteří se na překlady podílí (Byrne et al., 2009). Za určitý zlatý standard byla dlouho považována metoda zpětného překlady, kdy je test nejprve přeložen do cílového jazyka, následně někým jiným přeložen zpět do původního jazyka. Obě verze jsou pak porovnány. V případě, že se originál a zpětný překlady odlišují, můžeme u dané položky předpokládat neekvivalenci. Tato metoda je však v poslední době kritizována (Behr, 2016) například kvůli možné subjektivitě v porovnání obou verzí, značnému vlivu odborného pozadí a zkušeností překladatelů či závislosti na kvalitě instrukcí poskytnutých hodnotitelům zpětného překlady. Tyto faktory mohou vést k přehlédnutí chyb v překlady a k jeho neekvivalenci.

Metoda zpětného překlady není jedinou využívanou metodou překlady psychologických testů. Existují-li mezi cílovou a původní kulturou značné lingvistické a psychologické odlišnosti (např. překlady české metody pro diagnostiku českých Vietnamců první generace do vietnamštiny), metoda zpětného překlady nemusí být dostačující ke garanci ekvivalence překlady (Green, White, 1976). Mezi další techniky překlady patří metoda paralelního překlady, kdy jsou porovnávány nezávislé překlady několika překladatelů, nebo využití komise expertů, která hodnotí ekvivalenci překlady a navrhuje jeho změny do té doby, než komise dosáhne konsenzu (*committee approach*; Watkins, 2010). O decentraci (viz výše) lze mluvit také jako o jedné z metod využitelných při překlady testů. Při decentrovaném překlady považujeme jak originální, tak cílovou metodu za stejně důležité, obě je také možno modifikovat tak, aby byl výsledný překlady co neekvivalentnější (modifikovanému) původnímu testu (Ægisdóttir, Gerstein, Çinarbacs, 2008). Výše uvedené metody překlady je také možné různými způsoby kombinovat.

Mezi praktickými lingvistickými zásadami pro tvorbu a překlady testů můžeme uvést: a) využívat krátkých a jednoduchých vět, b) využívat činný slovesný rod, c) opakovat podstatná jména spíše než užívat zájmena, d) vyhýbat se užívání metafor, e) vyhýbat se užívání vágních slov, f) vyhýbat se užívání vět s více než jedním slovesem, g) využívat raději konkrétní než obecné pojmy (viz Malhotra, Agarwal, Peterson, 1996), h) vyhýbat se užívání slangu a idiomů, i) vyhýbat se výrazům a tématům, které mohou být danou kulturní skupinou považovány za nevhodné či urážlivé (ITC, 2017).

Na překlady testu a testových položek a ověření adekvátnosti použitého obrazového materiálu by mělo navazovat pilotní ověření (pretest). Jedná se o činnost, která bývá tvůrci testů často prováděna nedostatečně a může být zdrojem neekvivalence testu a v důsledku toho jeho neférovosti vůči určité kulturní skupině respondentů (ITC, 2017; Malda et al., 2008). Pretesty by měly být ideálně prováděny opakovaně, a to až do toho okamžiku, kdy se podaří eliminovat všechny zjevně lingvisticky a psychologicky neekvivalentní položky (Ægisdóttir, Gerstein, Çinarbacs, 2008).

V rámci úvah o ekvivalenci instrumentu je potřeba mimo samotného překlady zvážit další charakteristiky adaptované metody. Jsou všechny verze testu psány stejným fontem? Nevyskytují se v testu rozdílné instrukce? Jsou použité obrázky pro danou populaci pochopitelné? Jsou formáty odpovědí na položky pochopitelné pro všechny testované skupiny? Nemají testované skupiny problém s některými formáty otázek a odpovědí (ITC, 2017)?

Druhým z témat řazených pod ekvivalenci metody je ekvivalence administrace testu. Obecně je možno říci, že testujeme-li více různých kulturních skupin, snažíme se o minimalizaci vlivu stejných intervenujících proměnných způsobených odlišnostmi v administraci, jako při opakované administraci testu jedné kulturní skupině. Před administrací testu je vhodné (ITC, 2017) vytvořit detailní postup administrace (manuál), vyškolit administrátory, ověřit jejich schopnost administrovat test podle manuálu a snažit se test administrovat za co nejpodobnějších podmínek (čas testování, světlo a teplota v místě testování apod.). Administrace testu u různých kulturních skupin s sebou však přináší některé další nároky na osobu administrátora, interakci administrátora a respondenta a kontrolu testové situace.

V případě, že administrátor je z jiné kultury než respondent, je u respondentů možné očekávat určitou míru reaktivity na osobu administrátora a testovou situaci. Respondenti reagují na testovou situaci v souladu se svojí interpretací této situace. Mají tendenci odpovídat na položky testu v souladu s tím, co si myslí, že administrátor očekává (Leung, van de Vijver, 2008). Mohou se snažit vědomě snižovat rozdíly mezi svou kulturou a kulturou administrátora, nebo tyto rozdíly naopak přehánět, a tím posilovat svou etnickou identitu (Leong, Leung, Cheung, 2010). Jejich ochota odhalit se před administrátorem (např. u osobnostních dotazníků) se může lišit podle toho, pochází-li administrátor z „jejich“ či z „cizí“ kultury. Van de Vijver a Tanzer (2004) popisují tzv. efekt administrátora (*interviewer effect*), u kterého pouhá přítomnost administrátora z cizí kultury ovlivňuje odpovědi respondentů. Za nejvhodnější a vůči různým typům zkreslení nejodolnější lze považovat způsob administrace testu, kdy administrátor i respondenti pocházejí ze stejného etnika (Malhotra, Agarwal, Peterson, 1996).

Osoba administrátora a jeho vztah s testovaným může být zdrojem zkreslení na úrovni metody také v případě, že se respondent z nějakého důvodu cítí před experimentátorem nekomfortně. Tento pocit může být způsoben například vnímanými odlišnostmi v sociálním statusu mezi respondentem a administrátorem (Schaffer, Riordan, 2003), nebo u některých témat (např. u otázek týkajících se sexuality) a kultur (např. africké kultury a kultur Blízkého východu) také odlišným pohlavím administrátora a respondentů (Malhotra, Agarwal, Peterson, 1996).

Třetím tématem týkajícím se ekvivalence metody je ekvivalence vzorku (v tomto kontextu výběrového nebo standardizačního souboru). Ke zkreslení na úrovni výzkumného souboru dochází v případě, že zdrojem rozdílů ve výkonech v testu není rozdílná úroveň měřeného rysu, ale jiné systematické rozdíly mezi skupinami (Leung, van de Vijver, 2008). Řekněme, že budeme testovat inteligenci u vysokoškolských studentů z ČR a z Bangladéše a jedna ze skupin bude systematicky dosahovat lepších výsledků. Předpokládejme dále, že v tomto případě byl test inteligence velice dobře adaptován a administrován a nedochází tedy k jiným zkreslením na úrovni metody. Lze tento poznatek interpretovat jako skutečný rozdíl v inteligenci u Čechů a Bangladéšanů, nebo může být rozdílný výkon připsán i jiným příčinám? V tomto případě by mohla být hypotetickým zdrojem zkreslení například situace, kdy by na vysoké školy v Bangladéši bylo přijímáno pouze horních 5 % nejchytřejších studentů daného populačního ročníku. Vysokoškolsky vzdělaní Bangladéšané pak logicky budou dosahovat lepších výkonů než vysokoškolsky vzdělaní Češi, pro které je terciární vzdělání relativně otevřenější.

V interkulturních výzkumech a výzkumech zahrnujících minority může být problematická již volba metody výběru respondentů. Využití pravděpodobnostních metod výběru může být v případě hůře dostupných skupin (mezi které lze řadit i příslušníky českých menšin) nedosažitelným ideálem. V podobných výzkumech bývají častěji

využívány nepravděpodobnostní metody výběru, jako je kvótní výběr či výběr metodou sněhové koule. V krajních případech bývají u různých podsouborů využívány rozdílné metody výběru (např. pravděpodobnostní u majority a kvótní u minority; Malhotra, Agarwal, Peterson, 1996).

K neekvivalenci vzorku však může dojít i v případech, kdy srovnáváme dostatečně velké soubory respondentů, které jsou párovány podle relevantních demografických charakteristik. Dosáhnout perfektní srovnatelnosti souborů respondentů pocházejících z různých kultur či etnik je zpravidla velice obtížný úkol, doporučuje se však párovat respondenty zejména podle pohlaví a věku, socioekonomického statusu (sociální třídy) a velikosti sídla (Green, White, 1976). Van de Vijver a Tanzer (2004) u kognitivních testů doporučují sledovat také vliv proměnných jako je systém vzdělávání (v českých podmínkách například kvalita školy), zkušenost s testováním či motivace respondentů. Při následné analýze dat je pak vhodné všechny tyto sledované proměnné kovariovat s výsledky testu a odhalit tak jejich případný vliv na výkon v testu (Schaffer, Riordan, 2003).

Posledním tématem, které je tradičně řazeno do oblasti ekvivalence metody, je problematika tzv. stylu odpovídání (*response style*; He, Van de Vijver, 2013). Ten je ale zpravidla diagnostikován až ve fázi statistické analýzy dat.

Jako příklad excelentního využití a priori procedur při adaptaci kognitivního testu lze uvést studii, ve které autoři adaptovali Kaufmanovu hodnotící baterii pro děti (KABC-II; viz Malda et al., 2008). Základem jimi využitého způsobu adaptace je iterativní (vícekrát opakovaný) proces kvalitativního hodnocení testu a jeho následné úpravy s cílem maximalizovat porozumění respondentů testu a jeho jednotlivým položkám.

Test KABC-II (Kaufman, Kaufman, 2004) je původně americkým testem kognitivních schopností určeným pro děti a mládež mezi 3 a 18 lety. Test byl adaptován pro děti pocházející z nižších socioekonomických vrstev, které žijí v jihoindickém městě Bangalore a jejichž mateřským jazykem je kannadština (Malda et al., 2008).

V první fázi autoři adaptace (Malda et al., 2008) provedli terénní šetření – návštěvy škol a domovů dětí a rozhovory s jejich učiteli a rodiči – s cílem poznat úroveň kognitivní stimulace dětí a následně zvolit typ adaptace testu. Zajímali se například o množství a typy hraček, se kterými si děti hrály, o školní učebnice a další školní pomůcky, o styl vyučování v místních školách či o to, zda rodiny dětí vlastnily televizi. Ve druhé fázi proběhla samotná iterativní procedura a priori adaptace, ve které autoři ve spolupráci s místními experty testy překládali, pilotovali a modifikovali. Pro představu o jak časově a finančně náročný úkol šlo, lze uvést, že druhá fáze adaptace trvala celkem osm (!) měsíců.

Prvotní překlad byl proveden čtyřmi psychology mluvícími plynně anglicky i kannadsky. Překlad byl následně zpětně přeložen jiným překladatelem, několikrát pilotován a modifikován. Pilotní testování bylo administrováno nestandardně (tj. jinak než podle pokynů v manuálu). Cílem bylo identifikovat způsob, jakými děti uvažovaly o předložených otázkách a o odpovědích na ně. K dosažení tohoto cíle bylo využito techniky kognitivního interview (Willis, 2005). Dítě bylo u každé otázky požádáno o zopakování instrukcí, ověřovalo se, že instrukcím rozumí, následně nahlas uvažovalo o jednotlivých možnostech odpovědi a volilo dle své úvahy správnou odpověď.

Jednotlivé subtesty na základě své povahy vyžadovaly využití různých typů adaptace (Malda et al., 2008): 1) adaptace motivované teorií, 2) adaptace motivované odlišnostmi ve znalostech, 3) kombinace obou typů. Subtesty vybavování čísel (krátkodobá paměť) a Atlantis (dlouhodobá paměť) byly adaptovány na základě teoretických předpokladů, podle kterých byly vytvořeny. V případě vybavování čísel byla cent-

rálním bodem zájmu skutečnost, že počet jednotek, které je možné uložit do krátkodobé paměti, je závislý na jejich fonologické délce (viz model fonologické smyčky; Baddeley, Thomson, Buchanan, 1975). Je proto důležité držet konstantní délku slabik u číslic k zapamatování. Vzhledem k tomu, že číslice 2 a 9 jsou v kannadštině trojslabičné, bylo jejich použití v subtestu omezeno. U subtestu Atlantis (učení se nesmyslných slov ve spojení s obrázky a jejich následné vybavení) byl problémem rozdíl ve fonologické struktuře obou jazyků – děti měly problém s odlišováním fonologické struktury anglických nesmyslných slov, bylo potřeba vytvořit nesmyslná slova mající kannadskou fonologickou strukturu (Malda et al., 2008).

Adaptace motivovaná odlišnostmi ve znalostech byla provedena u několika subtestů zaměřených na měření zrakových schopností a fluidní inteligence. Zde si uvedeme pouze z našeho pohledu nejzajímavější příklady. Kannadské děti nejsou zvyklé pracovat pod časovým tlakem (Malda et al., 2008). Časové limity pro skórování správných odpovědí položek proto byly u několika subtestů na základě pilotního testování prodlouženy. Subtest dokončování příběhů (fluidní inteligence) v sobě obsahoval položky popisující životní situace běžné v americké populaci (nafukování balónků, oslava narozenin, smrkání do kapesníku), ale neznámé v populaci kannadských dětí. Byl proto kompletně nahrazen analogií subtestu řazení obrázků z testové baterie WISC-R. Obrázky byly překresleny lokálním umělcem s cílem eliminovat možné zdroje jejich nepochopení dětmi. Jako konkrétní příklad adaptace autoři uvádějí položku, ve které zloděj leze do okna domu a následně je chycen policií. Děti v originále nepoznávaly nápověď, že se jedná o zloděje (maska přes oči) a nepoznávaly ani okno (v originále vertikálně otevíratelné). V adaptované verzi má zloděj zřetelněji „indický“ vzhled a okno je otevíratelné do stran.

Výše popsané příklady a priori procedur adaptace demonstrují těžkosti, se kterými se autoři adaptací testů pro jiné kulturní či etnické skupiny musejí potýkat. Z příkladů je patrné, že ani položky relativně jednoduchých nonverbálních testů nemusejí být v různých populacích nositeli stejného významu, nemusejí být stejně dobře pochopitelné a stejně známé, jinými slovy nemusejí být nezávislé na kultuře (*culture-free*).

Statistická analýza dat

Po provedení všech kvalitativních procedur směřujících k adaptaci testu a sběru dat jsou zpravidla psychometricky testovány zdroje důkazů o validitě a reliabilitě metody (více viz Urbánek, Denglerová, Širůček, 2011), tedy zda metoda zjišťuje, co zjišťovat má, a jak přesně. Standardně bývá analyzována faktorová struktura škál pomocí explorační faktorové analýzy (dále EFA), či u známých struktur faktorových zátěží lépe pomocí konfirmační faktorové analýzy (dále CFA). Dále bývá posuzována reliabilita škál ať už ve smyslu stability v čase (test-retest), či ve smyslu vnitřní konzistence (paralelní formy, split-half, Cronbachova koeficientu α), případně testovány předpoklady o zdrojích validity metody (např. vzhledem k dalším metodám souběžné a diferenciální validity).

Tyto v ČR již rutinně používané postupy ovšem nejsou v případě adaptace testů pro jiné kultury a etnika považovány za dostatečné a přední odborné žurnály vyžadují využití dalších psychometrických postupů k ověření validity a reliability testových metod (Leung, van de Vijver, 2008). V části věnované různým typům ekvivalence již bylo zmíněno, že se různé zdroje neekvivalence konstruktů a metody mohou projevovat neekvivalencemi měření, neboli odlišným fungováním položek napříč populacemi (dále DIF). V metodologické literatuře zaměřené na oblast interkulturní psychologie existuje více různých typologií DIF (viz např. van de Vijver, Tanzer, 2004; van de Vijver, Poortinga, 2005), za nejpochoptelnější však považujeme členění na tři typy ekvivalence měření: a) ekvivalence struktury, b) ekvivalence metriky, c) ekvivalence

pravých skóru⁵. Tyto tři typy ekvivalence měření mají hierarchickou strukturu – ekvivalenci struktury lze považovat za nejnižší typ ekvivalence a ekvivalenci pravých skóru za typ nejvyšší. Bez dosažení (alespoň částečné) ekvivalence nižšího typu nelze dosáhnout ekvivalence vyššího typu (Davidov et al., 2014⁶).

Ekvivalence struktury se podobně jako již dříve zmíněná ekvivalence konstruktu zabývá otázkou shodnosti konstruktu napříč kulturními skupinami. Ekvivalenci struktury lze chápat jako ekvivalenci konstruktu operacionalizovanou v rámci konkrétního testu, tedy jako projev ekvivalence konstruktu v datech (van de Vijver, Poortinga, 2005). Statisticky analyzovat ji lze pomocí EFA, ale lépe pomocí konfirmační faktorové analýzy (*confirmatory factor analysis*). Výpočet ekvivalence struktury je v obou případech založen na porovnání podobnosti struktury faktorových nábojů (zda jsou náboje pozitivní, nulové či negativní) mezi příslušnými kulturními skupinami⁷. V rámci EFA přístupu je vypočten koeficient kongruence matic faktorových nábojů Tuckerovo ϕ (*Tuckers phi*; van de Vijver, Leung, 2001). Pro výpočty následujících, vyšších typů ekvivalence již však není EFA považována za vhodnou metodu a využívají se převážně CFA a víceskupinové strukturní modely (*multi-group structural equation modeling*, dále MGSEM). Statistická stabilita těchto technik však v závislosti na počtu proměnných, počtu faktorů a síle vazeb (Wolf et al., 2013) může klást vysoké nároky na velikost výzkumného souboru (Cheung, Au, 2005).

Vyšším typem ekvivalence, ekvivalencí metriky, hodnotíme, zda je latentní proměnná hodnocena napříč skupinami na stejné škále. Dosáhneme-li této úrovně ekvivalence, je možné mezi dvěma a více skupinami smysluplně porovnávat vztahy mezi latentním konstruktem a dalšími proměnnými (pomocí regresních koeficientů). Ekvivalence metriky je dosaženo, pokud mají všechny porovnávané skupiny podobné hodnoty faktorových nábojů (Davidov et al., 2012).

Ani po dosažení nižších typů ekvivalence není možné mezi populacemi smysluplně porovnávat průměrné hodnoty naměřeného rysu. To nám umožňuje až dosažení nejvyššího typu ekvivalence – ekvivalence skutečných skóru (Davidov et al., 2012). Jinými slovy, přestože daná metoda může napříč kulturami nebo etniky zjišťovat stejný konstrukt (ekvivalence struktury), a to na stejné škále (ekvivalence metriky), není zaručeno, že ho u jedné ze skupin systematicky nenadhodnocuje či nepodhodnocuje (neekvivalence skutečných skóru), tedy že rozdíly ve skutečných skórech jsou způsobeny rozdíly v latentních skórech a ne DIF (Steenkamp, Baumgartner, 1998). Při hodnocení této ekvivalence porovnááme mezi skupinami navíc hodnoty regresních konstant jednotlivých položek (Davidov et al., 2012).

Dosažení plné ekvivalence metriky a ekvivalence pravých skóru se v interkulturních empirických studiích často ukazuje jako nereálný cíl (viz např. Anýžová, 2014a; Lilleoja et al., 2016; Nye et al., 2008). V těchto případech je cílem výzkumníka dosáhnout alespoň částečné ekvivalence, která vyžaduje dosažení ekvivalence alespoň u dvou položek dané škály (Steenkamp, Baumgartner, 1998). Další možnosti jak se

⁵ Srovnej s Anýžová (2013, 2014b), která sice používá mírně odlišnou terminologii, ale její výklad může být pro čtenáře tohoto článku užitečný i díky tomu, že ho doprovází řadou názorných diagramů. Ve své empirické studii statistické ekvivalence Schwartzovy hodnotové škály (2014a) pak demonstruje postupy výpočtu ekvivalence u sebehodnotících škál.

⁶ Obsahuje přehled metod testování ekvivalence včetně moderních metod jako je Bayesovské strukturní modelování (BSEM) či přístupů založených na teorii odpovědi na položku. Přehled softwaru využitelného pro tyto typy testů uvádí např. Van De Schoot (Van De Schoot et al., 2015).

⁷ Pro detaily výpočtů jednotlivých typů ekvivalence lze nahlédnout do studií Davidov et al. (2012) nebo Steenkamp, Baumgartner (1998). Pro bližší informace o doporučených hodnotách jednotlivých indexů shody u CFA a strukturních modelů nahlédněte do Abubakar et al. (2015).

vypořádat s nepřítomností ekvivalence navrhuje Davidov (viz Davidov et al., 2014). Jedná se o (a) hledání podskupin výzkumného vzorku, napříč kterými je ekvivalence dosažena, (b) vypuštění neekvivalentních položek, či (c) vysvětlení zdrojů neekvivalence. V poslední uvedené možnosti dochází ke změně logiky věci – neekvivalence je zde chápána jako užitečný zdroj informací o meziskupinových rozdílech (takzvané MIMIC modely). Podle novějších pohledů (Byrne, van de Vijver, 2017) na ekvivalenci je v některých případech (zejména při velkém počtu srovnávaných skupin) prakticky nemožné dosáhnout vyšších typů ekvivalence pomocí klasických MGSEM přístupů a doporučují využití méně restriktivních statistických modelů přibližné ekvivalence (ESEM, BSEM).

Posledním tématem, kterému se zde budeme stručně věnovat, je problematika stylu odpovídání (*response style*) a zkresení odpovědi (*response bias*). I za předpokladu, že u daného testu ověříme ekvivalenci měření, nemůžeme si být jisti, že rozdíly mezi populacemi v průměrech či jiných použitých statistikách jsou skutečně způsobeny rozdíly v latentním rysu, a ne rozdíly ve stylu odpovídání (Davidov et al., 2012).

Styl odpovídání je řazen mezi zkresení na úrovni metody a je definován jako tendence respondentů odpovídat na položky nezávisle na jejich obsahu (Peterson, Rhi-Perez, Albaum, 2014). Styl odpovídání se projevuje hlavně u osobnostních dotazníků, dotazníků hodnot a postojů a podobných dotazníků využívajících jako formát odpovědi subjektivní sebehodnotící škály Likertova typu. Nejčastěji bývá rozlišováno několik stylů odpovídání (He, Van de Vijver, 2013): a) přitakávání (*acquiescence bias*, *yea-saying*), b) sociálně žádoucí odpovídání (*socially desirable responding*), c) odpovídání extrémů škály (*extreme responding*) a d) odpovídání středem škály (*midpoint responding*). Přítomnost zkresení odpovědi je možné testovat vhodnými metodami, jako je paralelní administrace škály sociální žádoucnosti či kalkulací indexů zkresení odpovědi (specifických pro jednotlivé typy zkresení).

Předpokládá se, že tendence volit různé body škály je ovlivněna kulturními faktory, jako je individualismus / kolektivismus a hodnoty dalších dimenzí kultury, míra konformity ve společnosti, socioekonomický status apod. (Johnson et al., 2005). Pokud se příslušníci českých minorit liší od majority v některých z výše uvedených faktorů, pak je u nich možné předpokládat i odlišnosti ve stylu odpovídání.

ZÁVĚR

Tento článek je věnován otázce, zda (a jak) testovat příslušníky národnostních menšin metodami, které byly původně vytvořeny pro většinovou populaci. Poznatky interkulturní psychologie nám poskytují konceptuální rámec pro uvažování nad možnostmi a podmínkami existence univerzálních psychologických rysů. Z řady výzkumů a zkušeností s adaptacemi metod z různých kulturních prostředí do jiných vyplývá, že různé varianty nebo úrovně univerzality rysů (a tudíž ekvivalence nástrojů jejich měření) nelze pouze automaticky předpokládat, ale je nutné je ověřovat, a pokud některé předpoklady neplatí, je třeba tomu přizpůsobit proces adaptace testu.

Tyto otázky úzce souvisejí s posouzením férového použití testů u příslušníků minorit, což nás dále vede k otázkám validity výsledků takových testových vyšetření. Protože validita závisí na kvalitě standardizace (včetně tvorby norem), přicházejí ke slovu různé postupy uvedené v tomto článku. Bez uvážení rozličných aspektů (ne)ekvivalence testových metod při použití u příslušníků různých kultur může být adaptace testu pro účely takového testování nevalidní a výsledky takových vyšetření pak mohou vést nejen ke zkresením ve výzkumných aplikacích těchto testů, ale v praktických aplikacích mohou vést k odborným pochybením.

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SOUHRN

Tento článek se zabývá problematikou ekvivalence testových metod a možnostmi jejich adaptace z jedné kultury do kultury jiné. Důraz je kladen na identifikaci rezerv, které má česká psychodiagnostika v oblasti testování menšin, a na metodologické postupy běžné v interkulturní psychologii, které lze využít v procesu adaptace testu s cílem dosáhnout co nejlepší validity výsledného testu pro cílovou populaci. Úvod článku se týká kulturní univerzality psychologických konstruktů, jednotlivými typy kulturního zkreslení a testovou ekvivalencí. Dále je pojednáváno o konkrétních typech adaptace testů a jednotlivých krocích a procedurách, které je nutné provést k vytvoření kulturně ekvivalentní verze psychologického testu.

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Appendix II

Study II



Psychometric Properties of the Independent and Interdependent Self-Construal Questionnaire: Evidence From the Czech Republic

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This article introduces a validation study of the Czech version of an independent and interdependent self-construal questionnaire (SCS, Vignoles et al., 2016) conducted on 330 Czech subjects. In this study, the reliability, convergent validity and factor validity were verified. However, the confirmatory factor analysis revealed unsatisfactory factor structure ($RMSEA = 0.053$ [0.048, 0.057], $SRMR = 0.080$, $CFI = 0.775$, $TLI = 0.755$). These results are discussed with respect to other adaptations of individualism/collectivism scales in countries beyond typical West-East dichotomy. Hence, the article not only critically discusses the shortcoming of the Czech and original versions of the questionnaires, but also the general issues of the individualism-collectivism construct in the cross-cultural context as a whole.

Keywords: individualism, collectivism, independent self-construal, interdependent self-construal, confirmatory factor analysis, psychometric properties, factor structure

INTRODUCTION

Formulated in the 1970s by Hofstede, the cultural dimension of individualism/collectivism (I/C) has become a popular theoretical concept in cross-cultural psychology and a useful tool to structure and measure the psychological characteristics of members of various cultures (Bond, 2002). Consequently, I/C is used as a predictor for many other psychological and behavioral variables (Oyserman et al., 2002). The I/C dimension was originally defined at a national level as a single bipolar dimension. Hofstede (1983) defined individualism as the quality of a relationship between an individual and his or her immediate social environment (family, friends, community, etc.). The theory of independent (*de facto* individualism) and interdependent (*de facto* collectivism) self-construal (Markus and Kitayama, 1991) later became the dominant approach in individual I/C research. It is based on the “social orientation hypothesis” (Varnum et al., 2010), which states that cultures differ in social orientations and their development. While some (individualistic) cultures adopt an independent social orientation and tend to emphasize self-direction, self-expression and autonomy, other (collectivistic) cultures endorse the development of interdependent social orientation and emphasize harmony, relatedness and connection with others. Even though individualism is currently rising in most societies, the mentioned cross-cultural differences remain detectable (Santos et al., 2017).

Despite the popularity of the construct, there is unfortunately no widely accepted method of measuring the individual level of I/C. Oyserman et al. (2002) identified 27 I/C scales and performed a content analysis of I/C domains. They found seven individualism and eight collectivism components accounting for 88% of the items across the scales. None of these 27 scales can be considered a single standard of measurement. The overall agreement on I/C operationalization differs in the selected scales from component to component, which has drawn attention to the fragmentation of the concept of I/C and its operationalization.

The debate on the number of factors and their structure is still ongoing and the existing research has suggested that the concept of an independent and interdependent self might be one-dimensional (Hofstede, 1983), two-dimensional (Markus and Kitayama, 1991; Lu and Gilmour, 2007), three-dimensional (Kashima and Hardie, 2000; Noguchi, 2007), four-dimensional (Singelis et al., 1995), five-dimensional (Bartoš, 2010) or possibly even seven-dimensional (Vignoles et al., 2016).

Such ambiguity raises a question about the true underlying factor structure and therefore calls for further investigation on independent samples (Bollen, 1989b). The importance of this step is even more crucial in cross-cultural research, where securing the equivalence of constructs as well as the measurement invariance is necessary to be able to compare country or cultural group means (van de Vijver and Tanzer, 1997; van de Vijver and Leung, 2001; Čeněk and Urbánek, 2019). In order to acquire some evidence of structural equivalence, statistical methods such as Confirmatory Factor Analysis (CFA), Multi-Group Confirmatory Factor Analysis (MG-CFA), Measurement Invariance (MI), etc., need to be applied (Fischer and Karl, 2019). Performing CFA is vital in cross-cultural research as a first step in verifying the possibility of comparing results across different questionnaire translations. This article is focused mainly on this step. The next steps after setting the configural model should lie in constraining the factor structure, factor loadings and intercepts and thus verifying the configural, metric and scalar invariance measurement across various cultural groups.

INDIVIDUALISM AND COLLECTIVISM IN THE CZECH REPUBLIC

Several previous studies have already been conducted on Czech participants with mixed results. Hofstede's (Hofstede et al., 2010) approach assigned an index of 58 to the Czech Republic, suggesting a slightly above-average level of individualism. In cross-cultural comparisons, Czechs have been shown to be more individualistic than the rest of countries in Central Europe (Kolman et al., 2003). Dumetz and Gáboriková (2017) study confirmed that the Czech Republic is more individualistic than Slovakia, but others found the exact opposite result (Bašnáková et al., 2016). Furthermore, the Czech Republic seems to be less individualistic than the Netherlands (Bašnáková et al., 2016) and less collectivistic and, similarly, individualistic as East Asians (Lacko et al., 2020). Another

study found that Czechs are not only more individualistic, but simultaneously also more collectivistic than Czech Vietnamese (Čeněk, 2015).

Unfortunately, these mixed results might be caused by the lack of valid and reliable tools to measure I/C, because adaptation attempts are relatively sparse for the Czech population. The first exception is an adaptation of INDCOL (Singelis et al., 1995) done by Bartoš (2010). However, his validation has a factor structure that does not fully correspond to the original scale, and its results are therefore not fully comparable in cross-cultural research. The psychometric properties of INDCOL are described in the next chapter.

The second exception, an attempt to adapt an I/C questionnaire into Czech, is a translation and cross-cultural verification of the Independent and Interdependent Self Scale (IISS; Lu and Gilmour, 2007) performed by Lacko and Čeněk (2020), who compared Czech and East Asian university students. Although the scale exhibited satisfactory reliability for both independent self-construal (Czech $\alpha = 0.815$, Chinese $\alpha = 0.929$) and interdependent self-construal (Czech $\alpha = 0.795$, Chinese $\alpha = 0.906$), the IISS showed configural non-invariance ($RMSEA = 0.043$ [0.025, 0.057], $SRMR = 0.144$, $CFI = 0.636$, $TLI = 0.617$). In their second study, performed on a larger sample consisting of only Czechs, they found similar unsatisfactory fit indices of IISS ($RMSEA = 0.064$ [0.061, 0.066], $SRMR = 0.104$, $CFI = 0.460$, $TLI = 0.432$).

The third exception is found in several adaptations of traditional methods measuring the cultural values, where individualism represents one of the cultural values. These Czech adaptations include VSM-94 (Value Survey Module 1994; Hofstede, 1994; adapted by Kolman et al., 2003), SVS (Schwartz Value Survey; Schwartz, 1992; adapted by Hnilica et al., 2006) and PVQ (Portraits Value Questionnaire; Schwartz et al., 2001; adapted in two studies by Řeháková, 2006; Anžžová, 2014). However, neither the original questionnaire manuals, nor the Czech adaptations of VSM-94 and SVS reported any relevant psychometric properties. The first study of PVQ reports only unsatisfactory internal reliability coefficients ($\alpha = 0.35$ – 0.70 ; Řeháková, 2006). Even though the second study revealed acceptable MG-CFA fit indices ($CFI = 0.924$, $RMSEA = 0.017$), it suggested insufficient MI results across countries (metric MI $\Delta CFI = 0.009$, scalar MI $\Delta CFI = 0.155$) and these results were applied only to 10 out of 23 countries in total (Anžžová, 2014), which therefore raises doubts about the validity and reliability of those instruments.

As mentioned above, the two-dimensional model of the IISS failed in the factor structure validation on the Czech sample, and Hofstede's one-dimensional model is claimed to be outdated and considered obsolete and invalid by many scholars (e.g., Singelis et al., 1995; McSweeney, 2002; Blodgett et al., 2008). Hence, the goal of this paper is to conduct an adaptation and psychometric analysis of a relatively new tool for individual level I/C measurement, the Self-Construal Scale (SCS; Vignoles et al., 2016; for a description see the Method section). Furthermore, we tried to verify its convergent validity with the current Czech adaptation of the Individualism-Collectivism Scale (INDCOL; Singelis et al., 1995; adapted by Bartoš, 2010).

MATERIALS AND METHODS

Participants

Data were collected from 330 Czech participants. This number of participants should be satisfactory for several reasons: (1) our proposed models are simple and they are composed only of several first-order factors and indicators (Kline, 1998); (2) even though the rules of thumb are not fully reliable while planning research, they usually indicate an amount of 100–200 participants as an absolute minimum (Little, 2013; Brown, 2015) and moreover, as Kline (1998) pointed out, the number of about 200 participants is not only very often used in the SEM framework, but it might also be reliable in certain circumstances; (3) no missing values were observed in our dataset (Brown, 2015; Kline, 1998); (4) I/C scales usually yield high internal-consistency reliability which decreases demands on sample size (Brown, 2015; Kline, 1998); (5) in single group models standard errors are significantly reduced with more than 150 responses (Little, 2013); and (6) our models yielded a huge number of degrees of freedom (Hoyle, 2012; Kline, 1998).

The research sample was 77% ($n = 254$) female. The participants were 18–65 years old ($M = 24.29$, $SD = 6.536$). Regarding the field of study, or vocation, 34.5% ($n = 114$) of the participants were psychologists/students of psychology, followed by students of/employees in the field of languages and history and of international studies (both 8.8%). Concerning the level of education, 58.8% ($n = 194$) had completed high school and 39.7% ($n = 131$) had achieved a university degree. Regarding the participants' religion, political preference and family status, most of them identified themselves as an atheist (43.6%), had no political preference (40.6%; or were liberals 31.2%) and were single (58.5%). The comprehensive descriptive statistics are shown in **Table 1**:

Procedure

Data collection was conducted between December 2018 - February 2019. The participants were mostly gathered through university social groups and social websites (i.e., the non-probability convenience sampling method) which resulted in a research sample with an over-represented student part of the population compared to other groups. The participants were informed about the ethical aspects of the research, especially data anonymization, their voluntary participation and the option to end the questionnaire at any time without giving a reason. In order to proceed further with the administration, they had to consent with their participation in the research. All items were administered randomly to avoid possible response biases caused by context influences and preceding questions (for review, see Uskul and Oyserman, 2006). The whole testing procedure took approximately 20 min.

In order to minimize any potential method bias caused by an imperfect translation procedure (van de Vijver and Hambleton, 1996) a parallel translation method was applied. The English original Self-Construal Scale (SCS) was independently translated by two bilinguals with backgrounds in social sciences.

Both translations were subsequently compared and, in the case of any inconsistencies, discussed by the authors of the study until an agreement on the formulation was reached. We put a special emphasis on minimizing any potential shifts of meaning between the English and Czech versions of the scale. The Individualism-Collectivism Scale (INDCOL) was used in the original Czech version (Bartoš, 2010). Both scales were administered online. In addition to SCS and INDCOL,

TABLE 1 | Demographic characteristic of sample.

Variable	Choice	Frequency
Gender	Man	76 (23.03%)
	Woman	254 (76.97%)
Age	Range	18–65
	Mean (SD)/median (IQR)	24.293 (6.536)/23 (4)
Family status	Single	193 (58.485%)
	In partnership	105 (31.818%)
	Married	24 (7.273%)
	Divorced	7 (2.121%)
	Widow	1 (0.303%)
Education	Primary school	2 (0.606%)
	High school	194 (58.788%)
	Higher vocational school	3 (0.909%)
	University	131 (39.697%)
Field of study/occupation	Psychology	114 (34.545%)
	International studies	29 (8.788%)
	IT	12 (3.636%)
	Pedagogy	19 (5.758%)
	Regional development	16 (4.848%)
	Information studies and librarianship	9 (2.727%)
	Languages and history	29 (8.788%)
	Other	102 (30.909%)
Salary of family during childhood	1300 CZK and less	21 (6.364%)
	1300–6500 CZK	84 (25.455%)
	6500–13000 CZK	130 (39.394%)
	13000–33000 CZK	79 (23.939%)
	More than 33000 CZK	16 (4.848%)
Religion	Atheist	144 (43.636%)
	Christianity	79 (23.939%)
	Spiritually based person	92 (27.879%)
	Other	15 (4.545%)
Political opinions	No preference	134 (40.606%)
	Liberalism	103 (31.212%)
	Environmentalism and green politics	45 (13.636%)
	Conservatism	24 (7.273%)
	Socialism	10 (3.030%)
	Nationalism	5 (1.515%)
	Anarchy	4 (1.212%)
	Other	5 (1.515%)
Number of siblings	0	51 (15.455%)
	1	161 (48.788%)
	2	78 (23.636%)
	3	26 (7.879%)
	4 and more	14 (4.242%)

all relevant socio-demographic variables were collected (see **Table 1**).

Measures

The Self-Construal Scale (SCS)

The SCS was developed by Vignoles et al. (2016) and validated on 9573 (Study 1, $n = 2294$; Study 2, $n = 7279$) participants across 55 cultural groups in 33 nations. The SCS is primarily based on the concept of independent and interdependent self (Markus and Kitayama, 1991). The authors built on other traditional I/C scales during the formulation of its items (e.g., Singelis et al., 1995).

The SCS consists of thirty-eight, nine-point, Likert-type numerical items scaled from 1 (not at all) to 9 (exactly), with three intermediate anchor-points (3 – a little, 5 – moderately, 7 – very well). The SCS contains half reversed items, which should enhance the validity of the factor structure and minimize the acquiescence bias (Smith et al., 2013).

The authors used exploratory and confirmatory factor analytic techniques, MG-CFA, multilevel analysis and other statistical procedures (such as modeling acquiescence as a common method factor in CFA or ipsatization for reliability estimation) in their validation study. Even though the authors did not perform an analysis of MI, they discussed it in relation to the items' factor loadings, which in their opinion suggested a satisfactory invariance. However, no reliability estimation was performed in the validation study. The SCS was also tested for response biases in their follow-up study (cf. Smith et al., 2016) as well as concurrent validity with the I/C dimensions measured by individualism values and in-group collectivism practices, where the r coefficients were between 0.425 and 0.752.

Using Principal Components Analysis (PCA) and Principal Axis Factoring (PAF) in the first study, the authors identified seven dimensions of the SCS, namely “Self-reliance vs. Dependence on others,” “Self-containment vs. Connection to others,” “Difference vs. Similarity,” “Commitment to others vs. Self-interest,” “Consistency vs. Variability,” “Self-direction vs. Receptiveness to influence” and “Self-expression vs. Harmony.” The CFA partially confirmed the factor structure in the second study. The authors presented two respective models: model 1, which was comprised of 38 items, and model 2, with 26 items. The first model yielded good fit indices despite an insufficient CFI ($SRMR = 0.050$; $RMSEA = 0.046$; $CFI = 0.790$). However, the authors claimed that a 0.90 threshold for CFI is often unreachable and unrealistic in multidimensional questionnaires used in various cultural samples and they justified a CFI value near 0.80 as acceptable for cross-cultural multidimensional questionnaires. The second model showed better fit indices ($SRMR = 0.033$, $RMSEA = 0.033$, $CFI = 0.922$) and can be considered valid from the point of view of factor structure. Nevertheless, this model only has 26 items and one subscale is consequently comprised of only two items, whereas an unabbreviated model contains four to six items per subscale. Our view is that 26 items are insufficient for a seven-dimensional questionnaire, and we therefore focused on the longer version of

the SCS. At the same time, we concur with the authors that the SCS is currently one of the most comprehensive tests available for I/C dimension measurement.

The Individualism-Collectivism Scale (INDCOL)

The INDCOL was introduced by Singelis et al. (1995) and later improved by Triandis and Gelfand (1998). The original scale contains 32 items, and the improved and shortened version contains 27 items. All items are nine-point, Likert-type questions. Both questionnaires measure four dimensions: horizontal collectivism (HC – empathy, cooperation, sociability), horizontal individualism (HI – independence, uniqueness, self-sufficiency), vertical collectivism (VC – submissiveness) and vertical individualism (VI – competitiveness). The validation study was conducted on 267 participants by Singelis et al. (1995). The reliability of scales was not ideal ($HI \alpha = 0.67$, $VI \alpha = 0.74$, $HC \alpha = 0.74$, $VC \alpha = 0.68$) nor were the CFA fit indices [$\chi^2(458) = 898.88$, $GFI = 0.79$, $AGFI = 0.75$, $RMSR = 0.089$]. Based on the CFA results, the item pool was reduced from 94 to 32 items. The questionnaire was improved by Triandis and Gelfand (1998) on 543 participants in total (Study 1, $n = 326$; Study 2, $n = 127$; Study 3, $n = 90$). They selected 27 items with the highest factor loadings and also reported higher reliability coefficients ($HI \alpha = 0.81$, $VI \alpha = 0.82$, $HC \alpha = 0.80$, $VC \alpha = 0.73$). The 27 INDCOL items also showed good convergent and divergent validity through correlations with I/C scenarios. However, they did not repeat the CFA for the 27-item questionnaire, nor did they perform MI.

The Czech validation study was conducted by Bartoš (2010) on 1081 participants. He modified the nine-point, Likert type items to seven-points and reduced the number of items to 24. He applied Exploratory Factor Analysis (EFA) to examine the factor structure of the Czech version of the INDCOL and found five factors. He separated HI into HI1 (uniqueness; 3 items) and HI2 (independence; 2 items). VI (7 items), HC (7 items) and VC (5 items) remained the same as in the original study. He also conducted reliability estimates, but two scales did not meet the minimum criteria ($VI \alpha = 0.79$, $HI1 \alpha = 0.71$, $HI2 \alpha = 0.60$, $VC \alpha = 0.63$, $HC \alpha = 0.76$). Although the Czech version of the scale seems to have limited psychometric properties, we decided to use it in this study for two reasons: (1) to verify its factor structure as reported by Bartoš (2010) using CFA on an independent Czech sample, and (2) to test its convergent validity with SCS, because it is, despite its limitations, the only available criteria for Czech samples.

Analytical Procedure

In order to examine the factor structure of both questionnaires, we performed a CFA with a robust, weighted, least square mean and variance (WLSMV) estimator, which is suitable for ordinal and non-Gaussian distributed data from Likert-type scales (Finney and DiStefano, 2013), because according to multivariate Henze-Zirkler tests, data were non-normally distributed at the subscale level (univariate Shapiro-Wilk tests confirmed these findings at the item level) for both questionnaires, and which is also less biased than robust maximum likelihood (MLR; Li, 2016). As the criteria for evaluating a good model fit, many more

or less strict cut-offs are used. We used the Tucker-Lewis Index (TLI) ≥ 0.95 , Comparative Fit Index (CFI) ≥ 0.95 , Root Mean Square Error of Approximation ($RMSEA$) ≤ 0.60 , Standardized Root Mean Square Residual ($SRMR$) ≤ 0.80 (Hu and Bentler, 1999) and Adjusted Goodness-of-Fit Index ($AGFI$) ≥ 0.90 (Hooper et al., 2008) fit indices for the evaluation of a good model fit in this study.

Internal consistency of subscales was assessed with Cronbach's α and McDonald's ω . We used the 0.70 threshold of internal consistency as a satisfactory indicator of reliability. We also performed a reliability analysis with ipsatization in order to reduce culture-specific response and acquiescence biases (Fischer, 2004; Fischer and Milfont, 2010). Standardized within-subject ipsative scores were calculated for each item of each individual according to the following formula:

$$\text{ipsative score} = \frac{\text{response} - M \text{ of scale for each individual}}{SD \text{ of scale or each individual}}$$

Convergent validity between and within measures was verified with nonparametric Spearman's correlation analyses, while each subscale score was entered into analysis as arithmetic mean. We interpreted correlation coefficients higher than 0.50 as indicators of minimally acceptable convergent validity and coefficients higher than 0.70 as sufficient evidence for convergent validity (Carlson and Herdman, 2010). The statistical analysis was conducted in R (v 3.6.1; R Core Team, 2020), specifically the packages *lavaan* (Rosseel, 2012), *semTools* (Jorgensen et al., 2018), *psych* (Revelle, 2020), *ShinyItemAnalysis* (Martinkova and Drabinova, 2018), and *MVN* (Korkmaz et al., 2014).

RESULTS

The descriptive statistics (means, standard deviations, skewness and kurtosis) of all scales are shown in **Table 2**. The item analysis within classical test theory approach (i.e., descriptive statistics of items, several types of discrimination, etc.) is reported in **Supplementary Appendix II**.

Factor Structure

The Czech version of the SCS showed satisfactory $RMSEA$ and $SRMR$. The relative chi-square (χ^2/df) was 1.913, which suggested a good global fit of the model (Kline, 1998). However, the model showed unsatisfactory CFI and TLI values. Nevertheless, we would like to emphasize that CFI of the Czech version of the SCS was almost the same as the CFI of the Vignoles et al. (2016) original version (see **Table 3**). A common factor with acquiescence as a common method factor was used on the reversed items following the procedure used by Vignoles et al. (2016) in order to reduce acquiescence bias (see Welkenhuysen-Gybels et al., 2003). This model also did not yield satisfactory fit indices.

Almost all of the items' factor loadings besides three instances were above the recommended 0.40 threshold (Fornell and Larcker, 1981). Even if we take into consideration the stricter thresholds, for instance 0.50 (Hair et al., 2018), we would obtain only four more such instances. Furthermore, the current factor loadings often being higher than the originals obtained by Vignoles et al. (2016; see **Supplementary Appendix I**). All item parameters, covariances (with two exceptions) and variances were statistically significant). Therefore, no items had to be removed from the model in order to improve its fit.

An analysis of the potential cross-loadings with a modification index (mi) and expected parameter change (epc) could bring deeper insight into model misfit. We found that item 32 (for items wording see **Supplementary Appendix I**) from "Self-expression vs. Harmony" had potential cross-loadings on subscales "Self-containment vs. Connection to others" ($mi = 155.075$, $epc = 0.869$), "Self-interest vs. Commitment to others" ($mi = 148.989$, $epc = 1.048$) and "Consistency vs. Variability" ($mi = 87.303$, $epc = -0.627$). Analogously, item 15 from Self-direction vs. Receptiveness to influence had potential cross-loadings on subscales "Self-containment vs. Connection to others" ($mi = 73.090$, $epc = 1.079$), "Consistency vs. Variability" ($mi = 68.539$, $epc = -0.746$) and "Self-interest vs. Commitment to others" ($mi = 57.856$, $epc = 1.239$). Item 35 from "Self-interest vs. Commitment to others" had potential cross-loadings on "Self-direction vs. Receptiveness to influence"

TABLE 2 | The descriptive statistics of subscale scores.

Scale	Subscale	M [95% CI]	SD	Skewness	Kurtosis
SCS	Difference vs. Similarity	5.59 [5.43, 5.75]	1.45	-0.143	-0.423
	Self-containment vs. Connection to others	4.28 [4.14, 4.43]	1.37	0.501	-0.122
	Self-direction vs. Receptiveness to influence	6.03 [5.88, 6.18]	1.40	-0.036	-0.726
	Self-reliance vs. Dependence on others	6.61 [6.44, 6.77]	1.50	-0.658	0.521
	Consistency vs. Variability	5.09 [4.91, 5.27]	1.67	-0.044	-0.460
	Self-expression vs. Harmony	5.02 [4.89, 5.16]	1.28	-0.121	-0.179
INDCOL	Self-interest vs. Commitment to others	4.66 [4.51, 4.81]	1.36	0.412	-0.167
	Vertical individualism	3.81 [3.68, 3.93]	1.15	0.240	-0.273
	Horizontal collectivism	5.21 [5.12, 5.31]	0.86	-0.498	0.247
	Vertical collectivism	3.41 [3.30, 3.52]	1.01	0.136	-0.244
	Horizontal individualism 1	4.88 [4.75, 5.01]	1.21	-0.623	-0.114
	Horizontal individualism 2	4.21 [4.07, 4.36]	1.34	0.107	-0.556

M, mean; SD, standard deviation; CI, confidence intervals.

TABLE 3 | The SCS and SCS modified model fit indices compared to the original version by Vignoles et al. (2016).

Model	Chi-Square	<i>p</i>	RMSEA [90% CI]	SRMR	CFI	TLI	AGFI
CZ SCS 1	χ^2 (644) = 1232.107	<0.001	0.053 [0.048, 0.057]	0.080	0.775	0.755	0.920
CZ SCS 2	χ^2 (625) = 1125.036	<0.001	0.049 [0.045, 0.054]	0.073	0.809	0.785	0.931
Original SCS	NR	NR	0.046 [NR]	0.050	0.790	NR	NR
CZ SCS Mod.	χ^2 (632) = 1011.010	<0.001	0.043 [0.038, 0.048]	0.066	0.855	0.839	0.943
CZ SCS (1 second-order factor)	χ^2 (658) = 1392.214	<0.001	0.058 [0.054, 0.062]	0.093	0.720	0.700	0.893
CZ SCS (bifactor)	χ^2 (606) = 975.433	<0.001	0.043 [0.038, 0.048]	0.060	0.859	0.836	0.951
CZ SCS (2 factors)	χ^2 (664) = 2013.118	<0.001	0.079 [0.075, 0.083]	0.121	0.485	0.454	0.824
CZ SCS 3	χ^2 (605) = 975.774	<0.001	0.043 [0.038, 0.048]	0.059	0.858	0.835	0.953

NR, not reported; CZ SCS 1, Czech version of SCS; CZ SCS 2, Czech version of SCS with one common factor with acquiescence as a common method factor on reversed items; Original SCS, original version of SCS; CZ SCS Mod., Czech version of SCS with allowed cross-loadings; CZ SCS (1 second-order factor), Czech version of SCS with one higher-order factor; CZ SCS (bifactor), Czech version of SCS with one general factor; CZ SCS (2 factors), Czech version of SCS two-dimensional model; CZ SCS 3, Czech version of SCS with two common factors with acquiescence as a common method factor separately on reversed and positive items; *p*, *p*-value; χ^2 , chi-square; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; CI, confidence intervals; AGFI, adjusted goodness of fit index.

TABLE 4 | The INDCOL fit indices compared to the original version by Singelis et al. (1995).

Model	Chi-Square	<i>p</i>	RMSEA [90% CI]	SRMR	CFI	TLI	AGFI
CZ INDOCL (5 factors)	χ^2 (242) = 521.126	<0.001	0.059 [0.052, 0.066]	0.074	0.779	0.748	0.932
CZ INDOCL (4 factors)	χ^2 (246) = 537.226	<0.001	0.060 [0.053, 0.067]	0.077	0.769	0.741	0.929
Original INDCOL	χ^2 (458) = 898.88	NR	0.089 [NR]	NR	NR	NR	0.75

NR, not reported; CZ INDCOL, Czech version of INDCOL; Original INDCOL, original version of INDCOL; *p*, *p*-value; χ^2 , chi-square; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; CI, confidence intervals; ECVI, expected cross-validation index; AGFI, adjusted goodness of fit index.

(*mi* = 61.102, *epc* = 1.124), “Self-expression vs. Harmony” (*mi* = 43.283, *epc* = 0.789) and “Self-containment vs. Connection to others” (*mi* = 39.786, *epc* = -1.486). Finally, item 25 from “Consistency vs. Variability” had potential cross-loadings on subscales “Self-direction vs. Receptiveness to influence” (*mi* = 55.498, *epc* = 0.563), “Self-interest vs. Commitment to others” (*mi* = 49.360, *epc* = 0.453) and “Self-containment vs. Connection to others” (*mi* = 48.192, *epc* = 0.485). These findings are discussed in detail in the Discussion section.

The analysis of modification indices showed that the SCS contained multiple cross-loaded items. If all of the above-mentioned cross-loadings are included in the model (CZ SCS Mod.; see Table 2 above), the majority of fit indices would be better than the original study by Vignoles et al. (2016). However, even these improved fit indices could still be considered unsatisfactory. Furthermore, using an exploratory approach (i.e., not confirmatory, cf. Bollen, 1989a; Byrne, 2010) we proposed four alternative models with individualism dimension as a one second-order factor of all subscales (i.e., CZ SCS 1 second-order factor), with individualism as a general factor in the bifactor model (i.e., CZ SCS bifactor), with individualism (non-reversed items) and collectivism subscales (reversed items in two-dimensional model (i.e., CZ SCS 2 factors) and with two common factors with acquiescence as a common method factor separately on reversed and positive items (i.e., CZ SCS 3, see Table 2). None of these models fit the data well.

The same CFA procedure was applied for the INDCOL scale with similar results as the SCS. The relative chi-square (χ^2/df) was 2.118, which suggested a good global fit. The RMSEA and

SRMR were satisfactory, however, the CFI and TLI were not. Hence, the current CFA results did support neither the 5-factor configural model provided by Bartoš (2010) nor the original 4-factor model provided by Singelis et al. (1995; see Table 4).

Reliability

Concerning the reliability of the SCS, Cronbach's α varied between 0.667 and 0.855, while McDonald's ω fell between 0.651 and 0.854 (see Table 5). The values of both coefficients showed satisfactory internal consistency in most of the subscales. Three subscales were slightly below the minimum threshold of 0.70. In case of ipsatization, α varied between 0.265 and 0.786. The results with ipsative scores were less satisfactory than the raw score results. This suggested that the questionnaire's items might have been potentially influenced by a response bias (especially

TABLE 5 | Reliability estimations of the Czech version of the SCS subscales.

Dimension	α SCS (ipsatized)	ω SCS
Difference vs. Similarity	0.759 (0.571)	0.771
Self-containment vs. Connection to others	0.697 (0.634)	0.707
Self-direction vs. Receptiveness to influence	0.670 (0.265)	0.674
Self-reliance vs. Dependence on others	0.772 (0.624)	0.774
Consistency vs. Variability	0.855 (0.782)	0.854
Self-expression vs. Harmony	0.651 (0.291)	0.651
Self-interest vs. Commitment to others	0.763 (0.463)	0.764

α , Cronbach's alpha; ω , McDonald's omega.

TABLE 6 | Reliability estimations of the Czech version of the INDCOL subscales.

Dimension	α INDCOL (ipsatized)	ω INDCOL
Vertical individualism (VI)	0.812 (0.642)	0.814
Horizontal individualism 1 (HI1)	0.564 (0.432)	0.483
Horizontal individualism 2 (HI2)	0.502 (0.510)	0.510
Vertical collectivism (VC)	0.589 (0.435)	0.577
Horizontal collectivism (HC)	0.739 (0.632)	0.737

α , Cronbach's alpha; ω , McDonald's omega.

the subscales “Self-direction vs. Receptiveness to influence” and “Self-expression vs. Harmony”).

Concerning the reliability of the INDCOL, α varied between 0.502 and 0.812 (for ipsative α between 0.432 and 0.642), while ω fell between 0.483 and 0.814 (see **Table 6**). The values of both coefficients demonstrated satisfactory internal consistency only for the VI and HC subscales. VC and HI demonstrated unsatisfactory internal consistency, and the ipsative scores suggested that they might have been influenced by a response bias.

Convergent Validity Between Measures

In the following section, the results of the correlation analyses between subscales of the original and adapted version of SCS, between subscales of the original and adapted version of INDCOL, and between scales of SCS and INDOL are reported. A comparison of Spearman's ρ to the original correlation coefficients (by Vignoles et al., 2016) in the subscales is shown in **Table 7**. All differences between obtained and original coefficients were smaller than 0.250. Besides a few exceptions, the Czech version showed relatively similar patterns of correlations to the original version. All of these associations were statistically significant and ranged from small to medium effect sizes (with exceptions of two insignificant associations and one association with high effect size).

A comparison of the Spearman's ρ correlations and original correlations of the Czech INDCOL version among the subscales is shown in **Table 8**. Even though current correlations were generally higher than correlations reported by Bartoš (2010), the correlations coefficients were still rather small. We also observed three differences between original coefficients and coefficients obtained in this study which were higher than 0.250. However, our results appear to be more in line with the I/C theory, because negative correlations between the HC (collectivism) and individualistic subscales (VI and HI2) were observed (instead of positive as reported by Bartoš, 2010).

Relationships were also expected between the SCS subscales and the INDCOL subscales as a demonstration of convergent validity. We assumed that HC and VC (i.e., collectivism) should be negatively correlated with all SCS subscales, whereas HI1, HI2 and VI (i.e., individualism) should correlate positively. As shown in **Table 9**, our expectations about directions were confirmed. However, these r_s coefficients were relatively small, and some of them non-significant. Only four associations were higher than 0.50 threshold (“difference vs. similarity” and “horizontal individualism: uniqueness”; “self-direction vs. receptiveness

TABLE 7 | Comparison of the estimated correlations in the Czech version (below diagonal) and the original version (above diagonal) of the SCS by Vignoles et al. (2016).

Dimension	1	2	3	4	5	6	7
1. Difference vs. Similarity	–	0.112	0.288	0.436	0.136	0.401	0.214
2. Self-containment vs. Connection to others	0.143** [0.035, 0.247]	–	0.625	–0.075	–0.219	0.330	0.557
3. Self-direction vs. Receptiveness to influence	0.299*** [0.197, 0.394]	0.405*** [0.311, 0.492]	–	0.328	–0.002	0.417	0.435
4. Self-reliance vs. Dependence on others	0.240*** [0.135, 339]	0.125* [0.017, 0.229]	0.479*** [0.391, 0.558]	–	0.301	0.132	0.104
5. Consistency vs. Variability	0.267*** [0.164, 0.364]	–0.008 [–0.116, 0.100]	0.243*** [0.139, 0.342]	0.193*** [0.086, 0.294]	–	0.252	–0.141
6. Self-expression vs. Harmony	0.450*** [0.360, 0.532]	0.246*** [0.142, 0.345]	0.424*** [0.331, 0.509]	0.180** [0.074, 0.283]	0.299*** [0.198, 0.394]	–	0.366
7. Self-interest vs. Commitment to others	0.334*** [0.234, 0.426]	0.619*** [0.547, 0.681]	0.468*** [0.379, 0.548]	0.300*** [0.199, 0.395]	0.043 [–0.065, 0.150]	0.443*** [0.352, 0.526]	–

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 8 | Comparison of the estimated correlations in the current (below diagonal) and original study (above diagonal) of the Czech version of INDCOL by Bartoš (2010).

Dimension	VI	HI1	HI2	VC	HC
VI	—	NR	NR	NR	0.19***
HI1	0.292*** [0.190, 0.388]	—	NR	−0.13***	−0.12***
HI2	0.241*** [0.136, 0.340]	0.112* [0.004, 0.217]	—	−0.13***	0.11***
VC	−0.083 [−0.189, 0.025]	−0.214*** [−0.314, −0.108]	−0.214*** [−0.315, −0.109]	—	NR
HC	−0.217*** [−0.318, −0.112]	−0.157** [−0.261, −0.050]	−0.308*** [−0.403, −0.207]	0.402*** [0.308, 0.489]	—

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; NR, not reported.

to influence” and “vertical collectivism”; “self-containment vs. connection to others” and “horizontal collectivism”; and “self-interest vs. commitment to others” and “horizontal collectivism”); none of them were above the recommended 0.70 value. Hence, these results do not support the assumption of the convergent validity of the SCS and INDCOL. It appears that both scales measure slightly different constructs.

DISCUSSION

The Psychometric Properties of the SCS

A validation study of the SCS was conducted and the psychometric properties of the SCS were examined. As Bollen (1989b) pointed out, the replication on independent samples is the only way to check whether original associations are a sampling fluke or not. He also emphasized the necessity of such research, because despite the fact that replications are often considered very valuable, such studies appear far too seldom. This type of research therefore serves as a contribution to the cross-cultural examination of the I/C concept and its results are necessary for a deeper understanding of I/C across various cultures.

In summary, both questionnaires demonstrated limitations in their reliability and validity. These shortcomings could have stemmed from the lack of reliability and validity of the original versions (Singelis et al., 1995; Triandis and Gelfand, 1998; Bartoš, 2010; Vignoles et al., 2016) rather than our cross-cultural adaptation.

In more detail, despite that Czech version of the SCS showed satisfactory reliability in four subscales (the rest of the subscales were only slightly below the 0.70), similar correlations between subscales were observed and similar fit indices were obtained in comparison with the original study (Vignoles et al., 2016). Additionally, our study revealed several crucial psychometric shortcomings of the scale which suggest its insufficient validity and reliability. This might be to some extent a consequence of the psychometric properties of the original instrument.

Four main issues were identified. First, the reliability estimation with ipsative scores showed poor internal consistency suggesting that the SCS may be influenced by response biases. Second, the CFA results were unsatisfactory, and therefore cross-cultural comparisons using this questionnaire might be biased, non-invariant and invalid (Fischer and Karl, 2019). Both the original and Czech versions of the SCS have serious shortcomings in their factor structure, as suggested by, for example, the *CFI*.

Consequently, the third issue stemmed from an analysis of the modification indices, which revealed some cross-loadings. For example, the item “*You follow your personal goals even if they are very different from the goals of your family*” might saturate not only “Self-interest vs. Commitment to others,” but also “Self-containment vs. Connection to others,” “Self-direction vs. Receptiveness to influence” and “Self-expression vs. Harmony.” This finding seems logical, because a person who answers negatively to the mentioned item is probably not only more committed to others, but also leans toward harmony and receptiveness to an influence and is more connected to others. The presented analysis suggests that many items have similar cross-loadings. We believe that this is probably more likely caused by the poor theoretical background in the latent variables than vague and ambiguous item wording. Consequently, SCS factors are vaguely defined and lack divergent validity because they are based primarily on psychometric results. Therefore, even simply worded items (e.g., the item “*You always ask your family for advice before making a decision*”) have potential cross-loadings on other subscales. Furthermore, the semantic qualities of some factors seem to be quite similar (e.g., “Self-direction vs. Receptiveness to influence” and “Self-interest vs. Commitment to others”), and perhaps may be adequate to reduce the number of I/C factors. Although the process of validation of a multidimensional cross-cultural questionnaire like SCS is very tedious, it should not be limited just to the psychometric evaluation of factor structure, model fit, reliability, etc., but it should also be theoretically well grounded.

And four, despite that all directions of relationships between SCS and INDCOL were as expected, i.e., the dimensions of horizontal and vertical collectivism correlated with interdependent self, whereas the dimensions of horizontal and vertical individualism correlated with independent self, the correlation coefficients were mostly small or moderate. This suggests, that both scales probably measure slightly different and insufficiently related constructs. The above-mentioned issues with the SCS lead us to questions about the I/C concept itself, because similar issues were observed in multiple previous studies (see below).

General Issues of the I/C Concept

Research of I/C has been criticized by many scholars. Generally, there is no questionnaire in the literature measuring I/C that repeatedly meets the demanding requirements of cross-cultural research (i.e., CFA, MG-CFA, MI across different cultures, controlling for response bias, etc.). Many studies do

TABLE 9 | Coefficients of Spearman's rho in the SCS and INDCOL.

Dimension	VI	HI1	HI2	VC	HC
Difference vs. Similarity	0.269*** [0.166, 0.366]	0.586*** [0.510, 0.652]	0.053 [-0.055, 0.160]	-0.347*** [-0.439, -0.249]	-0.098 [-0.204, 0.010]
Self-containment vs. Connection to others	0.154** [0.047, 0.258]	0.160*** [0.053, 0.263]	0.273*** [0.170, 0.370]	-0.389*** [-0.477, -0.293]	-0.561*** [-0.631, -0.482]
Self-direction vs. Receptiveness to influence	0.086 [-0.023, 0.192]	0.234*** [0.130, 0.334]	0.290*** [0.186, 0.386]	-0.552*** [-0.623, -0.473]	-0.285*** [-0.381, -0.182]
Self-reliance vs. Dependence on others	0.210*** [0.104, 0.311]	0.277*** [0.174, 0.374]	0.263*** [0.159, 0.361]	-0.324*** [-0.417, -0.223]	-0.155*** [-0.258, -0.047]
Consistency vs. Variability	-0.061 [-0.168, 0.047]	0.090 [-0.018, 0.196]	0.062 [-0.046, 0.169]	-0.139* [-0.244, -0.032]	0.099 [-0.009, 0.205]
Self-expression vs. Harmony	0.204*** [0.098, 0.305]	0.228*** [0.123, 0.328]	0.139* [0.032, 0.243]	-0.496*** [-0.573, -0.410]	-0.162** [-0.265, -0.055]
Self-interest vs. Commitment to others	0.370*** [0.273, 0.459]	0.336*** [0.237, 0.429]	0.325*** [0.225, 0.419]	-0.493*** [-0.571, -0.407]	-0.513*** [-0.589, -0.429]

p* < 0.05, *p* < 0.01, ****p* < 0.001.

not sufficiently conduct or report these important psychometric properties, and do not conduct any adequate multi-level analysis (Oyserman et al., 2002; Levine et al., 2003a,b; Chen and West, 2008; Cozma, 2011). Another relevant critique argues that the I/C research ignores or even lacks concurrent and discriminant validity of the scales (Oyserman et al., 2002; Levine et al., 2003b; Bresnahan et al., 2005; Schimmack et al., 2005). Furthermore, the conceptual unclarity of the I/C research is also often criticized (e.g., Oyserman et al., 2002; Voronov and Singer, 2002; Brewer and Chen, 2007; Oyserman and Lee, 2008).

As mentioned above, the original validation studies of INDCOL (Singelis et al., 1995; Triandis and Gelfand, 1998), SCS (Vignoles et al., 2016), VSM (Hofstede, 1994), SVS (Schwartz, 1992), and IISS (Lu and Gilmour, 2007) did not meet the minimum criteria of CFA or did not even perform such a procedure. Similar patterns can be found in other I/C questionnaires, for example in the W-M (Wagner and Moch, 1986), COS (Communal Orientation Scale; Clark et al., 1987), RISC (Relational-Interdependent Self-Construal; Cross et al., 2000), AICS (Auckland Individualism and Collectivism Scale; Shulruf et al., 2007) and ICIA scales (Collectivism Interpersonal Assessment Inventory; Matsumoto et al., 1997).

On the other hand, there are also several exceptions. For example, the Human Relations Questionnaire (HRQ; Noguchi, 2007) identifies three factors, namely the focus on others, helping others and self-focus, with satisfactory CFA indices: $\chi^2(24) = 49.93$, *GFI* = 0.973, *CFI* = 0.964, *RMSEA* = 0.052. Nevertheless, the author did not perform MG-CFA and MI analysis across the United States and Japanese versions, and its internal consistency was also not sufficient ($\alpha = 0.44-0.76$). Three factors were also identified in the RIC scale (Relational, Individual and Collective Self-Aspects; Kashima and Hardie, 2000), namely relational, individual and collective self-aspects. The RIC scale showed satisfactory CFA fit indices [$\chi^2(24) = 79.26$, *CFI* = 0.94, *NFI* = 0.91]; however, the CFA was supported by a nine-item model (only 3 items per subscale), not the original 30-item model (*CFI* = 0.72).

Other examples can be the PVQ (Schwartz et al., 2001), or the Collective Self-Esteem Scale (CSES, Luhtanen and Crocker, 1992). The PVQ provided an acceptable MG-CFA but insufficient MI results (Anýžová, 2014), while the four-dimensional CSES reached close to satisfactory CFA results (*NFI* = 0.74–0.91, *TLI* = 0.84–0.92, *CFI* = 0.87–0.93). However, the CSES factor structure was not confirmed in the African American ethnic group, and therefore we can doubt its usability in a cross-cultural equivalence (Utsey and Constantine, 2006). Additionally, both questionnaires also focus primarily on different constructs that only possess a partial overlap with the I/C concept, i.e., cultural values in the case of PVQ and collective self-esteem in the case of CSES.

In this paper we conducted an attempt to validate an adaptation of a relatively new I/C scale on a Czech sample which is a sample not fitting into the group of West and East countries (such as the United States, England, Japan, China) that are studied the most often in the field. In this section we want to provide information about other similar research going beyond this dichotomy, both successful and unsuccessful ones. We omit

adaptations without a CFA procedure or its adequate equivalent, which unfortunately represents the vast majority of studies (Chen and West, 2008). I/C scales were already successfully adapted for instance in Turkey (e.g., Li and Aksoy, 2006; Akin et al., 2010), Jordan, Lebanon, and Syria (e.g., Harb and Smith, 2008), Hong Kong and Ghana (e.g., Affum-Osei et al., 2019) or Switzerland and South Africa (results were satisfactory only for one of two used I/C scales; see Györkös et al., 2012).

Nevertheless, these successful attempts are relatively rare compared to the amount of studies that failed to do so. In spite of the fact that the authors themselves often interpreted the quality of the adaptations as satisfactory and part of studies is indeed methodologically and statistically sound, a deeper inspection reveals issues in the factor structure of the adapted scales. The adaptations usually did not yield satisfactory fit indices. In some cases, the number of factors and items were substantially changed compared to the original scales. Despite the fact that these model modifications and changes lead in some cases to the satisfactory fit indices of the “new” scales, this rather data-driven approach needs to be considered exploratory (see e.g., Bollen, 1989a; Byrne, 2010).

Similar psychometric problems with the adaptation of the I/C scale as in the current study were observed for instance in Poland (cf. Pilarska, 2011), Spain (cf. Gouveia et al., 2003), India (cf. Sivadas et al., 2008), Malaysia (cf. Miramontes, 2011; Ramley et al., 2020), Mexico (cf. Miramontes, 2011), Singapore (cf. Soh and Leong, 2002), Italy (cf. Bobbio and Sarrica, 2009; D’Amico and Scrima, 2015; Germani et al., 2020), France (cf. Gibas et al., 2016), Philippines (cf. Miramontes, 2011; Bernardo et al., 2012; Datu, 2014), Australia (cf. Freeman and Bordia, 2001; Miramontes, 2011), Portugal (cf. Gonçalves et al., 2017), Thailand (cf. Christopher et al., 2011) or Argentina (cf. Chiou, 2001).

The current, rather unsatisfactory results might have deeper causes than just the psychometric quality of the original SCS scale. Even though past studies assumed I/C being a stable cross-cultural construct with an ambition to categorize nations along the collectivistic and individualistic spectrum, these assumptions were not entirely confirmed. It seems that the relatively simplistic East-West dichotomy doesn’t truly exist (Matsumoto, 1999; Takano and Osaka, 1999, 2018; Heine et al., 2002; Oyserman et al., 2002; Levine et al., 2003a,b), and the I/C construct is far less stable than assumed (Yamagishi, 1988; Gardner et al., 1999; Oyserman and Lee, 2008). Consequently, some authors with respect to the previously mentioned shortcomings and critiques of I/C research came to the conclusion that the concept of I/C itself does not exist and suggest not using it in research (e.g., Levine et al., 2003a,b). Therefore, doubts about the validity of using I/C as a predictor of other constructs in current cross-cultural studies should be raised.

Limitations and Future Directions

The results of our study are based on the unrepresentative sample gained through the non-probability convenience sampling method which resulted in various imbalances of demographic characteristics, especially in the overrepresentation of women, young participants and participants with a university education. An analysis performed on different populations might result

in a different factor structure. However, I/C research usually validates the scales on samples of university students; for example, INDCOL (Singelis et al., 1995; Triandis and Gelfand, 1998) was created on the basis of such samples and SCS (Vignoles et al., 2016) used this population in the first phase of their validation study. Furthermore, despite the fact that sample size was considered satisfactory, SEM usually needs large samples and therefore is an *a priori* power analysis based on model simulations highly recommended (Hoyle, 2012; Little, 2013; Brown, 2015; Kline, 1998), which was not performed in the current study.

The future research should, in the first step, focus on a redefinition and reconceptualization of the I/C construct (e.g., Oyserman et al., 2002; Voronov and Singer, 2002; Brewer and Chen, 2007; Oyserman and Lee, 2008), while it is quite possible that such redefinition would not be universal for different cultural groups. Consequently, after the theoretical clarification of the I/C concept, the main aim of the future research should lie in a sounder methodological and statistical approach such as routinely using SEM techniques.

One of the possible ways to achieve this is the development of a new self-report instrument with satisfactory psychometric properties with the potential to be adapted in multiple cultures (Schimmack et al., 2005; Chen and West, 2008; Cozma, 2011). An important characteristic of this instrument would be its resistance to a reference-group effect (see Heine et al., 2002). Additionally, such an instrument would need to yield satisfactory results in repeated replications on independent samples from both the same and other cultures (Bollen, 1989b). Furthermore, adequate statistical approaches need to be used while comparing means across various cultural groups, such as MG-CFA with scalar measurement invariance (see Fischer and Karl, 2019). The research needs to be robust enough to cover the whole spectrum of variables that can potentially affect the level of I/C in order to reduce the cultural attribution fallacy (i.e., unpacking studies; see Matsumoto and Juang, 2013). Since the validation procedure usually does not end with one (un)successful validation study, but it represents an iterative process of bringing new evidence of validity and reliability the research in the field is far from concluded. However, we believe that without such an approach it is not possible to bring valid information about the real nature of I/C in culturally diverse populations via self-report scales.

The second possible approach to solve the current unsatisfactory situation in I/C research could lie in a shift from quantitative self-report questionnaires based on verbal responses to the usage of entirely different group of methods (e.g., Matsumoto, 1999; Bond, 2002; Fiske, 2002; Heine et al., 2002). For example, Talhelm et al. (2018) observed the differences in I/C with an observational design of the real-life behavior of participants; Partikova (2019) used interpretative phenomenological analysis of semi-structured interviews, and Hsu and Barker (2013) identified differences in I/C using the content analysis of TV advertisements. Furthermore, meta-analysis of other “cultural products” by Morling and Lamoreaux (2008) revealed higher effect sizes than meta-analyses performed on self-report scales. Another example can be found in the

work of Klein et al. (2018) who created a new “WEIRDness score” (WEIRD: Western, educated, industrialized, rich and democratic; see Henrich et al., 2010) which might be included into multi-group statistical analysis as a predictor in a similar fashion as Hofstede’s dimensions. We believe that it might be possible to create a similar country-level index specifically related to the I/C. Maybe not on the basis of self-report questionnaire data, but rather from an in-depth qualitative analysis of several indicators and consequent inter-rater agreement of experts from various cultures.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Research Ethics Committee of Masaryk University (Ref. No.: EKV-2018-011, Proposal No.: 0257/2018). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

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Written informed consent was implied via completion of the questionnaires.

AUTHOR CONTRIBUTIONS

DL contributed to data collection, article drafting, and data analysis. JČ contributed to questionnaire adaptation, data collection, and article drafting. TU contributed to article revisions and data analysis. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix III

Study III

Article is not Open access. Not part of public version.

Appendix IV

Study IV

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Appendix V

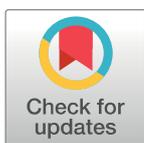
Study V

RESEARCH ARTICLE

Cultural variations in global and local attention and eye-movement patterns during the perception of complex visual scenes: Comparison of Czech and Taiwanese university students

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Abstract

Previous research on cross-cultural differences in visual attention has been inconclusive. Some studies have suggested the existence of systematic differences in global and local attention and context sensitivity, while others have produced negative or mixed results. The objective in this study was to examine the similarities and differences in holistic and analytic cognitive styles in a sample of Czech and Taiwanese university students. Two cognitive tasks were conducted: a Compound Figures Test and a free-viewing scene perception task which manipulated several focal objects and measured eye-movement patterns. An analysis of the reaction times in the Compound Figures Test showed no clear differences between either sample. An analysis of eye-movement metrics showed certain differences between the samples. While Czechs tended to focus relatively more on the focal objects measured by the number of fixations, the Taiwanese subjects spent more time fixating on the background. The results were consistent for scenes with one or two focal objects. The results of a correlation analysis of both tasks showed that they were unrelated. These results showed certain differences between the samples in visual perception but were not as systematic as the theory of holistic and analytic cognitive styles would suggest. An alternative model of cross-cultural differences in cognition and perception is discussed.

Introduction

Multiple research findings (for review see [1, 2]) suggest the existence of systematic cross-cultural differences in cognitive processing around the world. Much of the research investigates the cultural differences between “the East” (i.e. China, Japan, South Korea) and “the West” (i.e. Canada, USA, Western Europe) and anticipates the existence of systematic and relatively stable differences in cognition or cognitive styles.

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It is uncertain which factors cause variations in cognitive processes. It is reasonable to assume that they are based on the interplay of multiple factors that include sociocultural, environmental and biological influences, such as philosophical tradition [1], parent-child interaction [3, 4], socioeconomic status and personal wealth [5], literacy [6], the complexity of the physical environment [7], differences in the anatomical and functional aspects of the central nervous system [8, 9], or means of subsistence [10, 11]. Probably the most used explanatory factors for the existence of cultural differences in cognition are the cultural syndromes of individualism and collectivism (independent and interdependent self, respectively) [12, 13]. The theory of individualism/collectivism (and independence/interdependence, respectively) suggests fundamental differences in how individuals relate to society, how this relationship is constructed, and whether individuals or groups are the basic units of analysis. Collectivistic cultures are characteristic for emphasizing interdependence and orientation in social groups (e.g. extended families, communities). In individualistic cultures, emphasis is placed on individual independence and autonomy [12, 14].

Despite the growing body of literature on the topic, research in this area is far from complete. Besides the uncertain causal relationships between cognitive and cultural and environmental variables, at least two other “weak spots” or points of interest can be found in the existing body of research on holistic and analytic cognitive styles. First, despite several exceptions [5, 15–21], the research almost exclusively focuses on a simplified and reductionist comparison of “Western” (North America and Western Europe) and “Eastern” (East and Southeast Asia) populations, thereby ignoring all other cultural regions and the possible variations in cognitive processes in these regions. Furthermore, some evidence exists of the presence of differences in perceptual and cognitive processes, not only between people from different countries but also different regions within these countries [10, 19, 22]. Second, several recent studies have shown contradictory or mixed results, or minor effect sizes [21, 23–27], and call the theory of cognitive styles into question. Some advocate the prevalence of universal, bottom-up processes, while others acknowledge the need for replication in research on cognitive styles.

At least two models have attempted to explain the differences in cognitive style. Nisbett [1, 2] formulated a model (in the present paper, referred to as the “general holistic–analytic model”) of cognitive styles that is based on a vast amount of empirical evidence and that postulates systematic differences exist in cognitive processes between Easterners (holistic cognitive style) and Westerners (analytic cognitive style). More specifically, it describes differences in: (a) object categorization [28, 29], (b) reasoning about contradictions [30], (c) field dependence and object-background differentiation [31], (d) context sensitivity and selective attention on objects and relationships, (e) processing of global and local attributes of objects [32], (f) change detection [33, 34] and (g) memory [35]. If we accept the axioms of the general holistic–analytic model, holistic individuals (compared to their analytic counterparts) should: (a) use more intuitive and less rule-based strategies in object categorization, (b) use dialectical thinking instead of rules of formal logic, (c) have more problems with separating objects from the background, (d) focus more on the background and relationships between objects and less on the salient (or focal) objects and their attributes [15, 36], (e) focus more on the global and less on the local features of objects, (f) be more sensitive to the contextual and less to the focal object changes, and (g) recall objects in complex scenes less successfully. An important attribute of this model is that these differences should be coherent. This means that if a holistic individual focuses relatively more on the global features, he or she should also focus relatively more on the background. In other words, the scores obtained by multiple methods should be (cor) related.

Kozhevnikov et al. [37] proposed an alternative model (in the present paper, referred to as the “hierarchical–ecological model”) of cognition by emphasizing the ecological nature of

cognitive style, viewing cognitive styles as patterns of adaptation to the environment. According to this view, cognitive style is environmentally dependent, flexible and task specific. This model is based on Nosal's [38] earlier model; she proposed a hierarchical model of cognitive styles: a cognitive–style matrix that organizes cognitive styles along two axes or levels consisting of information processing (perception, concept formation, higher-order processing, meta-cognitive processing) and cognitive style families (context dependence and independence, rule-based and intuitive processing, internal and external locus, integration and compartmentalization). The most used cognitive styles are positioned along these axes. According to Kozhevnikov's model, the different cognitive styles would not necessarily have to (cor)relate since an environment might, for example, support both the development of global processing (holistic characteristic) and focus on salient objects (analytic characteristic).

In this research, the possible cross-cultural variations in two cognitive processes, (a) global and local attention and (b) context sensitivity, were examined in samples of Czech and Taiwanese university students. According to the research conducted by Hofstede [39], the Czech Republic is relatively high in individualism (individualism score = 58), while Taiwan is a typically collectivistic country (individualism score = 17). The selected samples therefore reflect the above-mentioned need to investigate samples beyond the traditional “USA vs. China/ Japan” borders, which is also logical from a theoretical point of view. Even though both countries have experienced unique and sometimes turbulent periods in recent history (wars, waves of migration, communist dictatorship, etc.) and are not seen as typical representatives of individualistic or collectivistic cultures, we might still assume the presence of differences in cognitive style. The psychology of people in the Czech Republic has been shaped by typically European influences, such as Christianity and Greek philosophy [1]. The country has a relatively less complex physical environment [7] and is a typical wheat culture [11]. Taiwan, however, is still part of the Asian cultural space, with Buddhism and Taoism as the main religions, a tradition of Chinese philosophy, a relatively more complex environment, and rice as a main means of subsistence. As such, we might expect Czechs (individualistic country) to perceive more analytically, while the Taiwanese (collectivistic country) to perceive more holistically.

To investigate global and local attention, a hierarchical Navon figures test was used. In the present study, we refer to our version of the PC-administered Navon figures test as the Compound Figures Test (CFT; see details in Materials and Methods section). This test presents figures at two hierarchical levels: global and local [32, 43]. The global level is generally represented by a letter (e.g. “H”), number (e.g. “3”), or shape (e.g. square). The global-level feature of the figure comprises multiple local-level features of the same type (e.g. local letters which form a global letter, or local numbers which form a global number).

Tests using hierarchical figures have been previously used in multiple cross-cultural examinations focused on processing the global and local features of objects [32, 40, 41]. With some exceptions [24], they report a relative advantage in the processing speed of global characteristics of stimuli (global advantage/precedence/preference) in Asian subjects compared to Westerners. The cross-cultural differences in context sensitivity (attention to an object vs. attention to the background) were examined using natural scenes (free-viewing paradigm) combined with eye-movement recording in a design similar to previous research conducted by other authors [15, 23, 36]. Some of the research found distinct differences in the eye-movement patterns between Chinese and Americans [36] and Chinese and Africans [15], while other enquiries supported a contradictory hypothesis on the lack of any systematic cultural differences in scene viewing [23].

The formulation of hypotheses in the present paper is based upon the general holistic–analytic model [2]. We formulate the hypotheses according to this model and not the competing model by Kozhevnikov [37] because most cross-cultural studies on the topic are also based on

this model and it offers a strong empirical basis for the formulation of such studies. As mentioned above, we applied two methods to assess the cognitive style of respondents and expected that performance in these methods would be modulated by cultural group. The hypotheses were formulated with respect to the metrics (scores) obtained by these methods. To examine the global vs local attention, we applied a CFT that has two main metrics to work with: a global precedence score (calculated as a difference in global and local reaction times; see the Stimuli section for details) and an error rate. In the second method, we investigated context sensitivity (attention to an object vs. attention to the background) in free-viewing task with a set of complex natural scenes (composed of one or two objects and a background; see the Stimuli section for details) combined with eye-movement measurement. The measurements included several common eye-tracking metrics, namely the number of first fixations, number of fixations, fixation time and transitions between parts of the scenes.

Global vs local attention (CFT)–a) The Taiwanese respondents should demonstrate a stronger global preference than Czech participants in CFT processing speed [32]. **CFT–b)** No significant differences in the error rate of responses between the two groups were expected [32]. **Context sensitivity (scene perception)–The Taiwanese respondents should:** a) make fewer first fixations on a focal object (percentage of first fixations on a focal object), b) make fewer focal object fixations (average number of focal object fixations), c) fixate focal objects for a shorter time (average focal object fixation time), d) make more background fixations (average number of background fixations), e) fixate backgrounds for a longer time (average background fixation time), and f) make more focal object to background transitions. In the case of stimuli with two focal objects, the Taiwanese were expected to h) make more direct transitions between both focal objects. In addition, because a cognitive style is defined according to the general holistic–analytic model as a complex set of behaviours, g) a correlation was expected between the eye-movement measurements in the perception of scenes and the global preference score of the CFT.

Scene perception related hypotheses a–e) were formulated according to the research by Chua et al. [36] and Duan et al. [15]. Hypotheses f–h) were based on the general holistic–analytic model, but were not, to our best knowledge, previously tested [1, 2, 42]. They reflect the assumption that holistic cultures “*tend to engage in context-dependent and holistic perceptual processes by attending to the relationship between the object and the context in which the object is located*” [42, p.1]. Furthermore, if the holistic and analytic cognitive style, as defined by the general holistic–analytic model [1], represents the quality of cognitive processes, where holistic perceivers compared to their analytic counterparts should, for example, perceive the global characteristics of stimuli relatively more quickly and also focus more on the relationships between objects in a scene, then the scores obtained by the methods measuring these qualities should also correlate with each other (hypothesis g)). If this is not the case, the hierarchical–ecological model [37] of cross-cultural differences in cognition might be more plausible.

Our research contributes by improving the understanding of cultural similarities and differences in visual attention and perception in at least three ways: (i) it is one of relatively few studies that explores multiple facets of cognitive style [24], (ii) it is, to our best knowledge, the first study to compare Asians and Central Europeans by measuring eye-movement patterns in viewing a scene, (iii) it is the first cross-cultural eye-tracking research that controls the number of focal objects in a scene (1 or 2).

Materials and methods

The Research Ethics Committee of Masaryk University has reviewed the application to conduct the research project and has approved this project (Proposal No.: 0257/2018) to be conducted on 13 March 2019. Informed consent was obtained in writing from all participants.

Stimuli

Besides the two experimental tasks described in this section, a personal questionnaire was administered and asked respondents to state their gender, age, experience in living in a foreign country (more than one year, yes or no), the size of their household before entering university and the current size of their household. All tasks were administered in either Czech or traditional Chinese according to the cultural background of the participant.

Compound Figures Test. To assess global and local distribution of attention, we applied a Compound Figures Test: a numerical PC version of the original Navon test [43]. CFT has been applied in previous studies [44–47]. The test was administered using the Hypothesis software [48, 49].

In each task, the participant was presented with a large (global) number (Fig 1A) comprising multiple smaller (local) numbers. In the CFT, only four numbers were used as global and local numbers: 2, 4, 5 and 8. The participant was instructed to identify either the global (global task) or local level of the stimulus (local task) and select from four possible responses (one correct answer and three distractors) the correct answer as quickly as possible with a mouse-click. Before the test, the participant was given three practice trials and received feedback whether their response was correct. The participant did not proceed unless he or she selected the correct answer in each practice trial. The entire test comprised six practice tasks (three local and three global) and 32 test trials (16 for local and 16 for global processing). The local task preceded the global task in all cases. A fixation cross was displayed for 0.5 seconds before each trial (Fig 1B).

The reaction times and error rate of the responses were measured in each test. The mean speed and error rate of the local and global tasks were calculated separately. Four average values were therefore recorded for each participant: global reaction time (RT), local reaction time, global error rate, and local error rate. The main score, or the global preference score, was calculated in the CFT [24, 32] as local RT-global RT and served as a major indicator of local and global attention. Let us remind that we assumed the Taiwanese respondents would demonstrate a stronger global preference than Czech participants in CFT processing speed. The error rate of responses was a control variable, i.e. a high number of mistakes indicated the

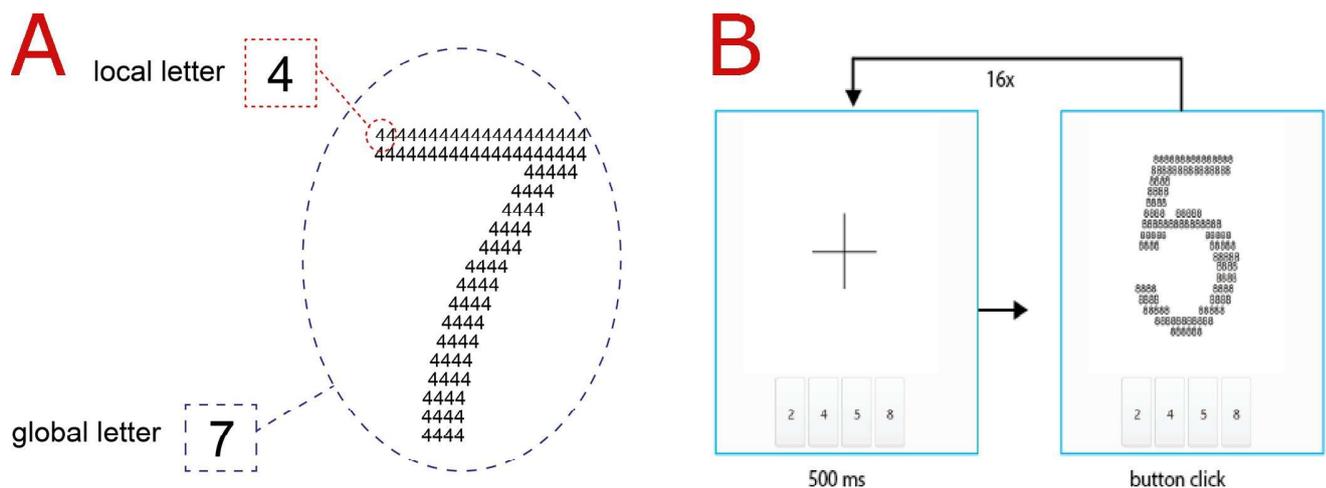


Fig 1. CFT stimulus example and procedure. (A) CFT stimulus. (B) CFT procedure. A fixation cross is displayed for 500 ms before each stimulus. After the fixation cross is displayed, a compound letter is presented. Depending on the task (local vs. global), the participant identifies the local or global feature of the stimulus and responds by pressing the corresponding number.

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decreased validity of the test results due to, for example, less motivation or misinterpretation of the test. No significant differences in the error rate of responses between the two groups were therefore expected.

Complex scenes. To investigate the possible cultural differences in context sensitivity of the two samples, 60 images of real-world scenes were used. The pictures were downloaded from free online image depositories (wallpaperflare.com, pxhere.com). Half of the scenes were similar to those used in other research [15, 23, 36], consisting of one focal object (animals or inanimate objects such as vehicles, buildings, doors and windows on a facade) against backgrounds of different complexity (Fig 2A and 2B) from relatively uniform to moderately complex. The other half of the stimuli were similar but contained two focal objects (Fig 2C and 2D) of the same category. In the scenes containing one focal object, the object was positioned either centrally (10 images), at the left (9 images), or at the right (11 images). In the scenes with two focal objects, the positions of the objects were not controlled. The scenes for both groups were the same size (1024 x 688 px) and the scenes were placed on the black background.

The participants were instructed to view a series of pictures and evaluate how much they liked each picture on a scale of 1 to 5 (1 –very good, 5 –very poor). These data were not analysed. Two practice runs preceded the testing. A fixation cross was displayed before each test until the moment the participant fixated on it. After the participant successfully fixated on the cross, it disappeared, and an image was displayed for four seconds.

This timing was selected according to previous research on perceiving scenes using different durations to display stimuli. For example, Chua et al. [36] and Evans et al. [23] displayed the stimuli for three seconds, and Duan et al. [15] displayed stimuli for five seconds. Chua et al. [36] showed that the proportion of object fixations varied throughout the course of testing. After a stimulus was displayed, participants mostly fixated on focal objects (bottom-up process driven by salience) for around 300–400 ms. The proportion then varied throughout the testing, and any potential differences in fixation count and duration may have disappeared after a long enough (e.g. 10 s) exposure to the scene [26].

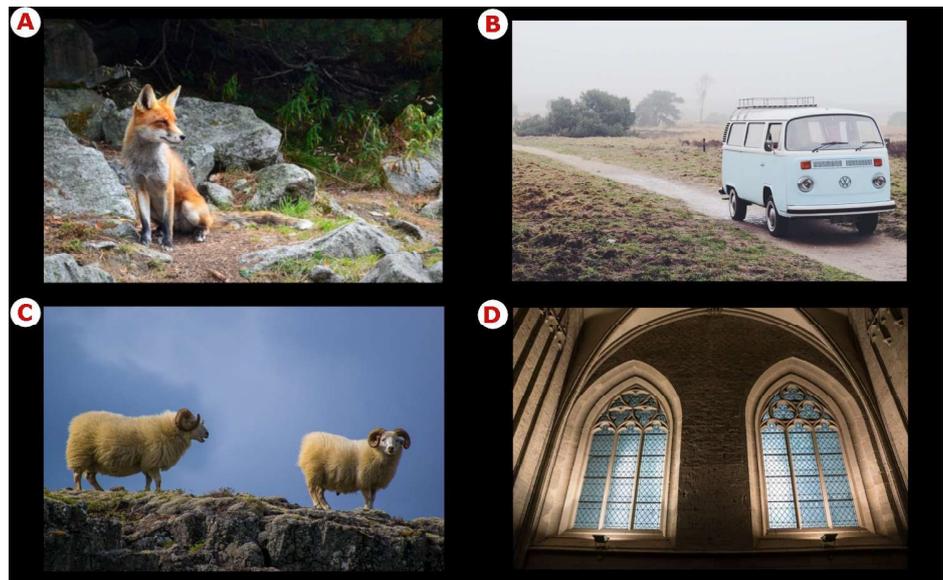


Fig 2. Examples of real-world scenes. (A), (B) Samples of one focal object scenes. (C), (D) Samples of two focal object scenes. Copyright statement: All images used in this figure are free for commercial and personal use.

<https://doi.org/10.1371/journal.pone.0242501.g002>

The testing was presented in two separate batches: pictures with one focal object and pictures with two focal objects. A one-minute break was given between the batches. The sequence of batches was balanced: half of the participants first viewed the batch with one focal object and the other half viewed the batch with two focal objects. The sequence of pictures in each batch was pseudo-random. The eye-movement data were recorded for each test.

Apparatus

The CFT data were collected using Hypothesis software (see above) and the Google Chrome web browser. The participants viewed the stimuli without a chinrest. In Taiwan, a 19" (EIZO FlexScan S1901) LCD monitor with a resolution of 1280 x 1024 was used. The viewing distance was approximately 65 cm. In the Czech Republic, a 22" (AOC I2267FW) monitor with a resolution of 1680 x 1050 was used. The viewing distance was approximately 70 cm. The size of the instructions with illustrative examples and size of the stimuli (the compound hierarchical letters) were the same for both groups (900 x 675 px and 440 x 500, respectively).

In Taiwan, eye-movements were tracked with an EyeLink 1000 desktop type eye-tracker. The stimuli were presented on a 19" (ViewSonic P95f+) CRT monitor with a resolution of 1024 x 768. In the Czech Republic, eye-movements were tracked using an SMI Red eye-tracking system with an integrated 22" monitor (Dell P2213) with resolution of 1680 x 1050 px. The size of stimuli was same in both countries (1024 x 688 px). A chin rest positioned approximately 70 cm away from the monitor was used to minimize any disruptions caused by head movements. The visual angle of stimuli in Czech Republic was approximately 31.5° horizontally and 21.5° vertically. The visual angle of stimuli in Taiwan was approximately 30.1° horizontally and 21.8° vertically. In both countries, the sampling rate was set to 500 Hz, with 9 points of calibration. The minimum accuracy of calibration was set to 1° of visual angle. The same threshold was used for all participants.

Participants and procedure

The test battery was translated using the parallel translation method, which is commonly used to reduce method bias in cross-cultural test adaptations [50, 51]. Two bilinguals translated the test materials (test instructions). Both versions were then assessed for any potential differences. If the translations differed, the differences were discussed by the research team until a consensus on optimal translation was reached.

The research participants in both countries were recruited through university groups on social networks. Participation was limited to people of Czech or Taiwanese nationality possessing no eye-diseases or colour blindness and normal or fully corrected vision. A formal administration procedure was created, and the process of administration in both countries, including the instructions given to participants and the task sequence, remained the same. The test battery was administered in both countries by a local administrator (Czech and Taiwanese, respectively) to prevent a potential method bias [52]. Administrators of the test battery at both sites were also trained to administer the battery in the same manner. The test battery was administered in the following sequence: after entering the laboratory, participants a) read and signed an informed consent form, b) filled in a sociodemographic questionnaire, c) completed the CFT, and d) completed the complex scenes task.

The minimum required sample size was estimated before the experiment commenced using G*Power 3.1 [53] for ANOVA, fixed effects with effect size = 0.25, $\alpha = 0.05$, Power = 0.8, and 4 groups (2 [area: object vs. background] \times 2 [nationality]). The required total sample size was 128 respondents. In total, we gathered data from 129 participants (60 Taiwanese, 69 Czechs). The detailed procedure of data cleaning and number of participants in each of the

Table 1. Research sample characteristics summary.

Variable	Taiwanese (N = 60)	Czech (N = 69)
% of women	71.6	71.0
Age–Mean (SD)	21.1 (2.07)	21.5 (2.65)
% of participants living abroad for longer than a year	8.3	14.5
Household size–Mean (SD)	4.1 (1.16)	4.0 (1.16)

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statistical analyses are described in the respective sections of the Results. See [Table 1](#) for a summary of the sample's characteristics.

In the present paper, we used the following statistical programmes: G* Power 3.1 [53] for power analysis; R 3.5.2 [54] for eye-tracking data pre-processing and statistical analysis; Ogamma 5.0.1 [55] for eye-tracking data cleaning, ROI (Regions of Interest) definition and fixation calculation. Stimuli, data files, R scripts and procedural descriptions are publicly available in the OSF repository (<https://osf.io/eubwn/>; DOI [10.17605/OSF.IO/EUBWN](https://doi.org/10.17605/OSF.IO/EUBWN)).

We applied the following analyses. The cultural differences in the CFT were tested with independent samples and paired sample t-tests. Cultural differences in the scene perception task were tested using mixed ANOVAs with one between-subject factor (cultural group) and one within-subject factor (ROI), post-hoc tests, and independent sample t-tests. In all analyses, partial eta squared (η^2 ; ANOVA) and Hedges' g (g; post hoc tests, t-tests) effect sizes were calculated. Finally, for an exploratory analysis of relationships between the main eye-tracking metrics and other variables, we used linear regression.

Results

Analysis 1: Compound Figures Test

In the first stage, the average error rate and average reaction time (speed) scores were computed for the local and global tasks (16 trials for each subtest). The error rate score was taken as an indication that the participant understood the task correctly. If the error rate of a certain participant was high, the participant was excluded from further analysis. Before the data were cleaned, the overall average error rate was 0.9% for the local task and 3.0% for the global task. The Taiwanese participants had a slightly higher average error rate in both local (1.0%) and global (4.9%) tasks compared to the Czech participants (0.8% for local and 2.2% for global). The maximum number of errors in the local task was one (corresponding to an error rate of 6.25%—out of 16 trials in total). Several participants (6 Taiwanese, 2 Czechs) had higher error rates in the global task. The number of errors in a task greater than four (corresponding to a 31.3% error rate—out of 16 trials in total—or higher) cannot be attributed to a temporary lapse in attention or “mouse misclick”, but rather suggest a misunderstanding in the nature of the task. When we removed these eight participants from the data set, the overall average error rate in the global task dropped to 3.4%. The average error rate of Taiwanese (1.2% for local and 1.5% for global) and Czech (0.8% for local and 1.3% for global) participants was almost identical, and the differences were not significant, with negligible effect sizes (global task: $t(101.59) = 0.26$, $p = 0.795$, $g = 0.048$; local task: $t(99.11) = 0.69$, $p = 0.487$, $g = 0.130$). In the next stage of CFT data cleaning, we examined the average processing speed of global and local tasks. One Taiwanese participant was excluded from further analysis as an extreme outlier (reaction time for a local task more than 11 standard deviations from the group mean).

After data cleaning, the data from 120 respondents (53 Taiwanese, 67 Czechs) were analysed according to reaction time. The data for reaction times are summarized in [Table 2](#). The data shows that both the reaction times and variability were generally higher in the Taiwanese

Table 2. Summary of statistics for reaction times and global preference by nation (in seconds).

Measurement		Taiwanese (N = 53)	Czech (N = 67)
Local RT (sec)	Mean	2.06	1.02
	SD	0.255	0.132
	Median	2.04	0.97
	IQR	0.242	0.143
Global RT (sec)	Mean	1.89	0.89
	SD	0.229	0.139
	Median	1.86	0.87
	IQR	0.324	0.210
Global preference (Local RT–Global RT)	Mean	0.17	0.13
	SD	0.180	0.116
	IQR	0.252	0.143

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sample. The mean reaction times were also higher in the local task. To test the differences in global vs. local RTs in each group, we performed two paired t-tests separately for both nationalities. The differences were significant for global vs local RTs in both the Czech sample ($t(66) = 8.98$, $p = 4.692e-13$), 13 with a large effect size ($g = 0.936$), and for the Taiwanese sample ($t(52) = 6.89$, $p = 7.413e-9$), 9 with a medium effect size ($g = 0.699$).

For reaction times, we subsequently calculated the global preference score using the *local RT–global RT* equation, a procedure used in multiple studies with Navon-type hierarchical stimuli [24, 32, 56, 57]. We applied an independent t-test to determine the differences in global processing between both groups. No significant differences were found between the Taiwanese ($M = 0.17$, $SD = 0.180$) and Czech ($M = 0.13$, $SD = 0.116$) participants, $t(84.646) = 1.51$, $p = 0.136$. The effect size was small ($g = 0.289$).

Analysis 2: Complex scenes

Eye-movement data pre-processing. The differences in data format created by using two different eye-tracking systems forced us to pre-process the eye-movement data before calculating the eye-metrics in Ogama. For this purpose, R 3.5.2 [54] was used. The cleaned data was subsequently imported into Ogama [55]. In Ogama, the following steps were performed: a) data loss analysis, b) definition of ROIs, c) calculation of fixations, d) fixation detection verification. Data loss in the entire sample was relatively low. In the case of Czech participants, data loss varied between 0.13 and 13.77% (mean = 2.89), and in the Taiwanese participants, between 0.02 and 6.99% (mean = 2.91). Two (stimuli with one focal object) or three (two focal objects) ROIs were defined. The ROIs for focal objects were defined around their contours, and the background ROI covered the entire image except for the focal objects and black borders (Fig 3).

Fixations were calculated next. Ogama uses a dispersion-type algorithm [58] to detect fixations. We used the settings suggested by Popelka [59]: maximum distance of 15 pixels, minimum number of 40 samples, size of 31 pixels for the fixation detection ring, automated elimination of first fixation and no merging of consecutive fixations. The number of fixations was checked for each participant and stimulus to identify participants with potential problems in fixation detection (extremely low or high numbers of fixations). Nine participants (8 Czech, 1 Taiwanese) were discarded from further analysis.

As mentioned above, the data for this task were cleaned using a two-step procedure. We first conducted a data loss analysis and then calculated fixations, verifying whether they were



Fig 3. ROIs. (A) Sample one focal object image with ROI. (B) Sample two focal objects image with ROI. Copyright statement: All images used in this figure are free for commercial and personal use.

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correct. From this, we eliminated 13 participants because of the quality of their eye-tracking data. The most common reason for excluding participants was problematic detection of fixations: 8 participants indicated an extremely low number of fixations per trial (e.g. 0 or 1), while the common numbers of fixations per trial were much higher (entire sample median = 12). We excluded participants with median fixations per trial of less than 9. One respondent demonstrated the opposite behaviour: an extremely high number of fixations per trial (median = 22). Both effects were clear indications of a problem in detecting fixations (caused, for example, by shimmering glasses). We also lost the data of three participants due to system error during recording. One participant was discarded for high data loss (13.8% of lost data). After the participants with faulty and missing eye-tracking data were removed, the final analysed sample comprised 116 participants (58 in both groups).

Eye-movement data analysis. We expected that Taiwanese and Czechs would show different eye-movement patterns, suggesting differences in visual attention between both groups. More specifically, we analysed the percentage of first fixations on focal objects, the numbers of fixations on focal objects and backgrounds, the focal object and background fixation time, and the transitions between the ROIs. Because two different types of stimuli based on number of focal objects were used, stimuli with one or two focal objects were analysed separately. The parameters for all eye-tracking metrics and for both types of stimuli are summarized in [Table 3](#).

One focal object. We first calculated the proportions of first fixations from all first fixations on the focal object. The data shows that in most cases, both Czech ($M = 91.0$, $SD = 8.2$) and Taiwanese ($M = 92.6$, $SD = 7.2$) participants first fixated on the focal objects. The

Table 3. Summary statistics of eye-tracking metrics for all stimuli according to nationality (fixation time in milliseconds).

Stimulus type	Nationality	One focal object Mean (SD)		Two focal objects Mean (SD)	
		Czech	Taiwanese	Czech	Taiwanese
Fixations	% of first fixations on FO	91.0 (8.2)	92.6 (7.2)	98.7 (3.9)	98.3 (2.9)
	Number of FO fixations	8.2 (1.3)	6.8 (1.1)	8.7 (1.7)	7.5 (1.1)
	Number of BG fixations	4.6 (1.2)	4.6 (1.3)	4.0 (1.1)	4.5 (1.1)
	FO fixation time	1949 (383)	2023 (353)	1982 (436)	2035 (299)
	BG fixation time	966 (264)	1218 (290)	838 (235)	1138 (231)
Saccades	Number of within FO saccades	6.3 (1.3)	4.5 (1.0)	4.4 (1.1)	3.2 (0.8)
	Number of within BG saccades	2.8 (1.0)	2.6 (1.2)	2.2 (0.9)	2.3 (0.9)
	Number of FO–BG transitions	3.7 (0.7)	3.6 (0.7)	3.7 (0.8)	3.9 (0.7)
	Number of FO–FO transitions	NA	NA	2.4 (0.8)	2.0 (0.6)

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differences were not significant: $t(114) = 1.163$, $p = 0.247$, with a small effect size ($g = 0.214$). The focal object in most cases was first fixated on by both cultural groups.

Both groups showed significantly more fixation counts on focal objects than the backgrounds in the mean number of fixations: $F(1, 228) = 308.78$, $p = 2e-1616$, $\eta^2 = 0.58$. The main effect of culture was significant: $F(1, 228) = 17.92$, $p = 3.34e-0505$, $\eta^2 = 0.07$, as was the interaction between culture and ROI: $F(1, 228) = 19.07$, $p = 1.91e-0505$, $\eta^2 = 0.08$. Fig 4 indicates that the Czech participants ($M = 8.2$, $SD = 1.3$) made significantly more focal object fixations than the Taiwanese ($M = 6.8$, $SD = 1.1$), $t(114) = -6.229$, $p = 8.079e-0909$, with a large effect size $g = 1.15$. No significant differences were found between the Czech ($M = 4.6$, $SD = 1.2$) and Taiwanese ($M = 4.6$, $SD = 1.3$) participants in the number of background fixations, $t(114) = -0.093$, $p = 0.93$, $g = 0.02$.

In fixation time, both groups spent more time observing the focal object than the background: $F(1, 228) = 436.05$, $p = 2e-1616$, $\eta^2 = 0.66$. The main effect of culture was significant: $F(1, 228) = 14.51$, $p = 0.00020002$, $\eta^2 = 0.06$, as was the interaction between culture and ROI type: $F(1, 228) = 436.05$, $p = 0.038038$, $\eta^2 = 0.02$. No significant differences were found between the Czech ($M = 1949$, $SD = 383$) and Taiwanese ($M = 2023$, $SD = 353$) participants in focal object fixation time, $t(114) = -1.080$, $p = 0.283$, $g = 0.20$. The Taiwanese ($M = 1218$; $SD = 290$) fixated longer on the background than Czechs ($M = 966$, $SD = 264$) in background

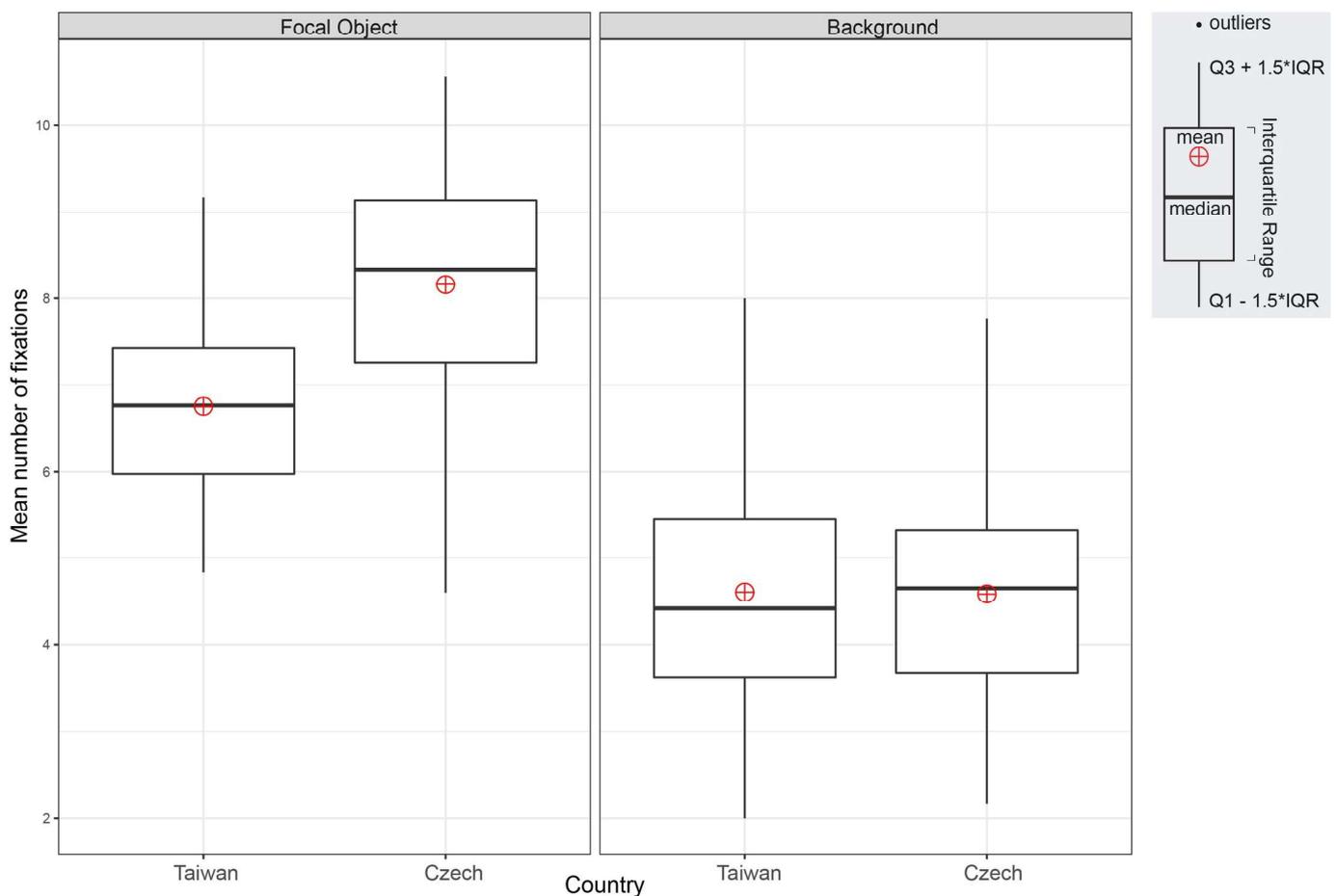


Fig 4. Mean number of fixations: One focal object stimuli.

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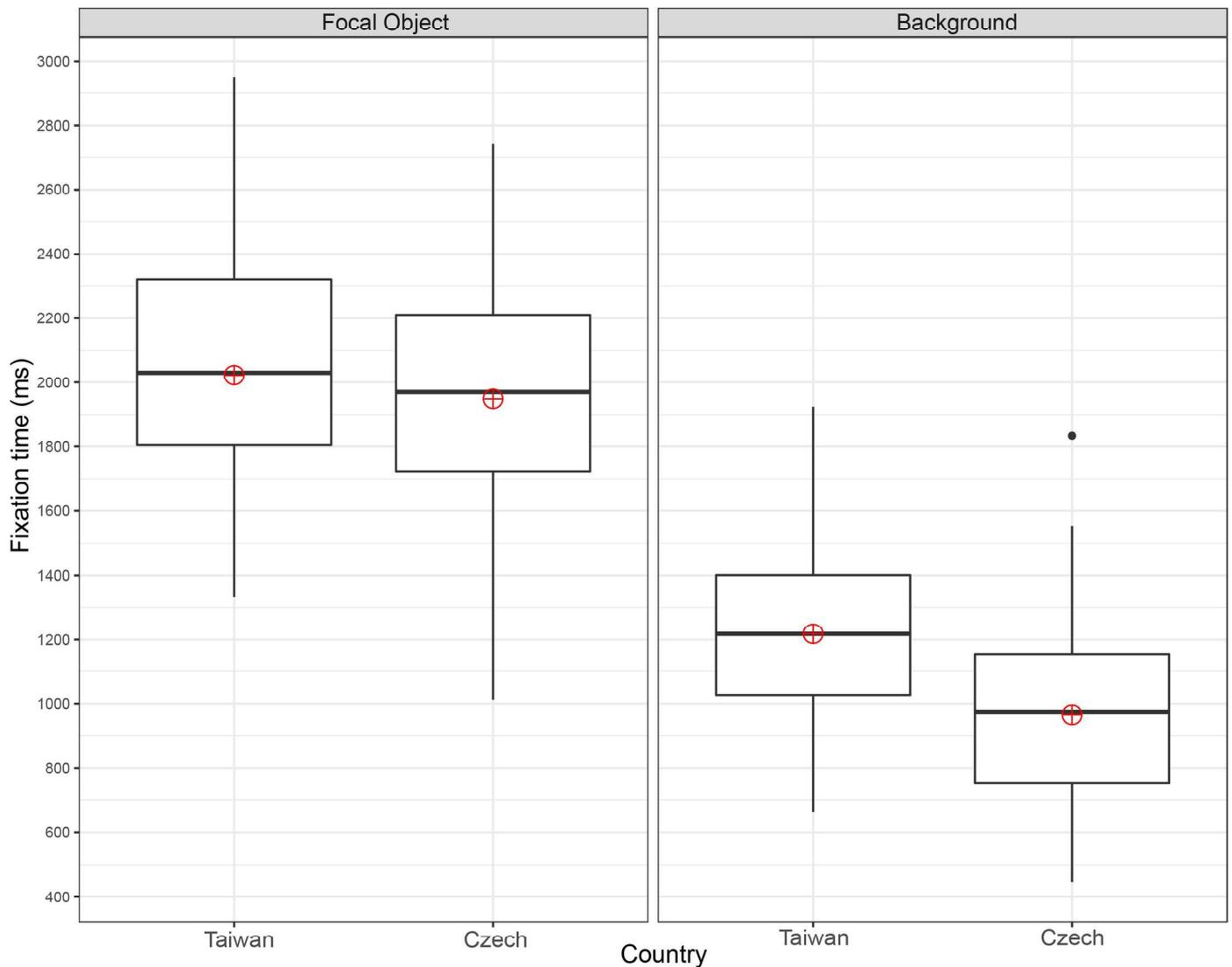


Fig 5. Mean fixation time: One focal object stimuli.

<https://doi.org/10.1371/journal.pone.0242501.g005>

fixation time, $t(114) = 4.903$, $p = 3.161e-0606$, with a large effect size $g = 0.90$ (Fig 5). We also tested for focal object to background transitions. No differences in the number of transitions were found between the Czech ($M = 3.7$, $SD = 0.7$) and Taiwanese ($M = 3.6$, $SD = 0.7$) participants, $t(114) = 0.494$, $p = 0.623$, $g = 0.09$.

Two focal objects. The same analyses were performed for stimuli with two focal objects. The proportion of first fixations was not significantly different in the Taiwanese ($M = 98.3$, $SD = 2.9$) and Czech ($M = 98.7$, $SD = 3.9$) groups, $t(114) = -0.628$, $p = 0.531$, with negligible effect size $g = -0.116$. One focal object was significantly first fixated on by both cultural groups.

In terms of the number of fixations, both groups fixated more on focal objects than backgrounds $F(1, 228) = 532.04$, $p = 2e-1616$, $\eta^2 = 0.70$. The main effect of culture was significant: $F(1, 228) = 4.65$, $p = 0.032$, $\eta^2 = 0.02$, as was the interaction between culture and ROI: $F(1, 228) = 26.15$, $p = 6.7e-0707$, $\eta^2 = 0.10$. Fig 6 indicates that the Czechs ($M = 8.7$, $SD = 1.7$) made significantly more fixations on focal objects than the Taiwanese ($M = 7.5$, $SD = 1.1$), t

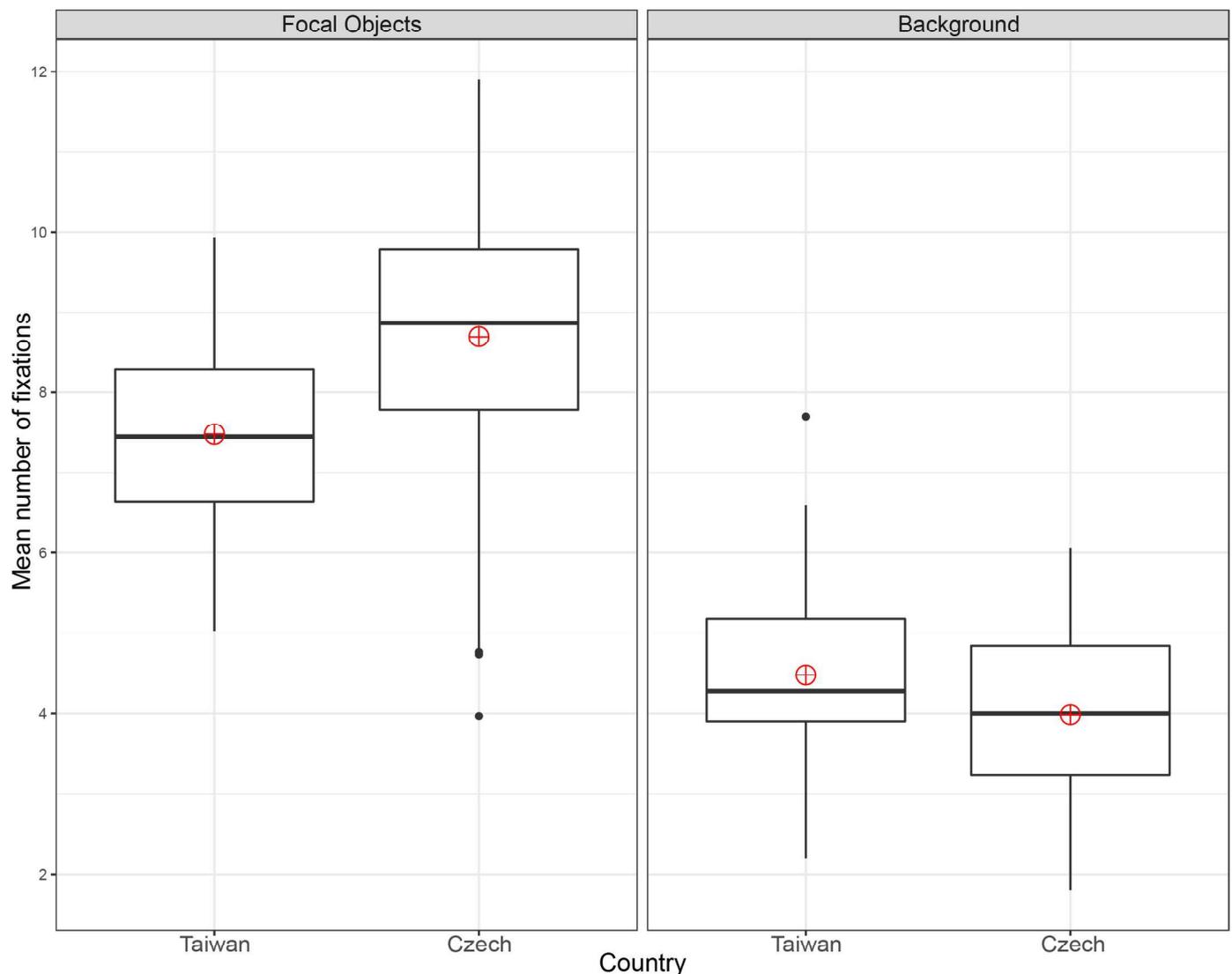


Fig 6. Mean number of fixations: Two focal objects stimuli.

<https://doi.org/10.1371/journal.pone.0242501.g006>

(114) = 4.595, $p = 1.123e-0505$, $g = 0.85$. By contrast, the Taiwanese ($M = 4.5$, $SD = 1.1$) participants fixated on the background significantly more than their Czech counterparts ($M = 4.0$, $SD = 1.1$), $t(114) = 2.417$, $p = 0.017$, with small effect size $g = 0.45$.

In terms of fixation time (Fig 7), both groups observed the focal objects longer than the background: $F(1, 228) = 622.67$, $p = 2e-1616$, $\eta^2 = 0.73$. The main effect of culture was significant: $F(1, 228) = 18.70$, $p = 2.29e-0505$, $\eta^2 = 0.08$., as was the interaction between culture and ROI type: $F(1, 228) = 18.70$, $p = 0.002$, $\eta^2 = 0.04$. No significant differences were found between the Czech ($M = 1982$, $SD = 436$) and Taiwanese ($M = 2035$, $SD = 299$) participants in focal object fixation time, $t(114) = -0.765$, $p = 0.446$, $g = 0.14$. The Taiwanese participants ($M = 1138$; $SD = 231$) also fixated on backgrounds significantly longer than the Czechs ($M = 838$, $SD = 235$), $t(114) = 6.953$, $p = 2.379e-1010$, with large effect size $g = 1.28$.

Finally, the number of transitions in both groups was compared. In this case, both transitions between focal objects and background and transitions between focal objects were

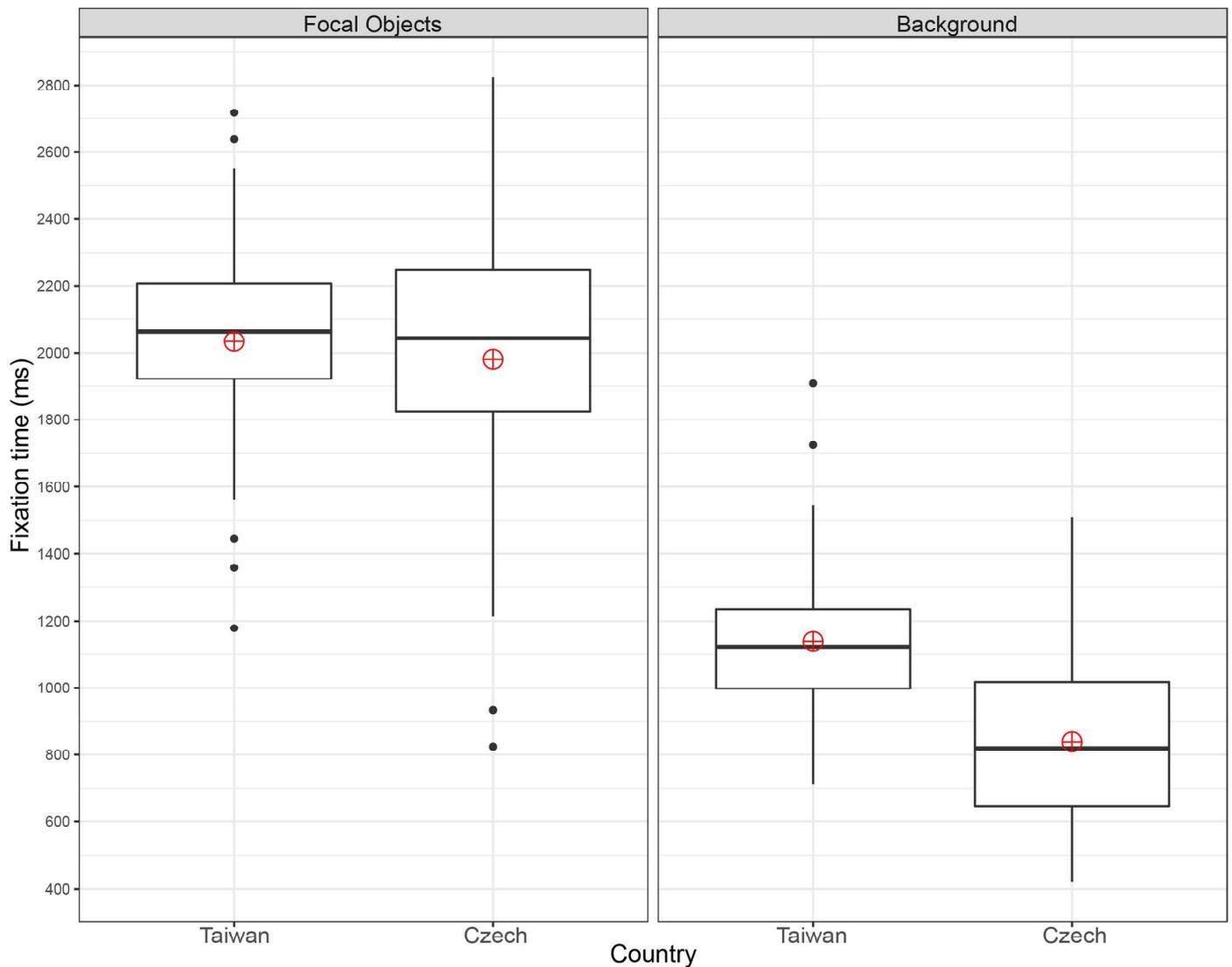


Fig 7. Mean fixation time: Two focal objects stimuli.

<https://doi.org/10.1371/journal.pone.0242501.g007>

analysed. While no significant differences were consistently found in one focal object stimuli between the Czech ($M = 3.7$, $SD = 0.8$) and Taiwanese ($M = 3.9$, $SD = 0.7$) participants in the focal object to background transitions, $t(114) = -1.322$, $p = 0.189$, $g = 0.24$, the Czech participants ($M = 2.4$, $SD = 0.8$) transitioned significantly more between the two focal objects than the Taiwanese ($M = 2.0$, $SD = 0.6$), $t(114) = 2.939$, $p = 0.004$, $g = 0.54$.

Analysis 3: Relationship between eye-movement metrics, CFT and other variables

Only data from respondents not excluded from one of the two previous analyses (CFT, complex scenes) were part of this analysis. We calculated 108 cases (56 Czech, 52 Taiwanese). To determine whether the eye-tracking metrics had any relationship with other collected variables, we calculated a relative focal object/background number of fixations, fixation times and

number of saccades by dividing the focal object metrics of each participant with their background metrics. A series of three multiple linear regressions was subsequently performed on CFT global preference scores, sex, age, household size, experience with living abroad and nationality as independent variables, and relative number of fixations, relative fixation times and relative number of saccades (each in a separate model) as dependent variables. We expected a significant positive relationship between CFT global preference and the relative eye-tracking variables, meaning that the more global the attention patterns, the more the focal objects were focused on. We did not hypothesize any relationships between eye-tracking metrics and other variables included in the models for exploratory purposes.

Nationality was a significant predictor of the relative number of fixations: $F(6, 101) = 2.82$, $\Pr(>|t|) = 0.00239$, with an adjusted R^2 of 0.092, relative fixation time: $F(6, 101) = 2.65$, $\Pr(>|t|) = 0.00273$, with an adjusted R^2 of 0.085, and relative number of saccades: $F(6, 101) = 2.25$, $\Pr(>|t|) = 0.011$, with an adjusted R^2 of 0.065. No significant regression equation was found for any other variable in these three tested models. When nationality was excluded from the models, the adjusted R^2 of the models had a maximum value of less than 0.006. That means the focal object to background eye-tracking patterns appeared to be independent of the global preference scores and sociodemographic variables mentioned above, except for the participants' nationalities.

Discussion

The present study introduces several new findings into the ongoing debate on cross-cultural similarities and differences in visual perception and cognition according to the theory of holistic and analytic cognitive styles [2, 29]. The study examined two dimensions of cognitive style: global vs. local attention (measured by CFT) and context sensitivity (measured by eye-tracking metrics as complex scenes were perceived). In summary, both Czech and Taiwanese showed a strong global preference effect in the CFT: global processing speed was significantly quicker compared to local feature processing. No significant differences were found between the groups in the global preference scores. No cultural differences were noted as affecting the proportion of first fixations on focal objects in the eye-tracking metrics calculated in the scene perception task. Both groups fixated more frequently on and spent more time observing the focal objects than the background. Czech participants fixated more frequently on focal objects than the Taiwanese, while the Taiwanese spent more time observing the background. The results were consistent across one and two focal object scenarios. No differences were found between the groups in the number of focal object/background transitions. The Czech participants made more direct transitions between focal objects in the dual focal object scenario. No significant relationships were found in the relative (focal object vs background) eye-tracking metrics, such as number of fixations, fixation time, number of saccades, CFT, global preference score, sex, age, household size or experience living abroad.

Compound Figures Test

As mentioned above, global vs. local attention was investigated using a CFT [43]. The tasks consisted of two sub-tasks that would indicate a person's tendency for global (attention to global characteristics) vs. local (attention to local characteristics) processing. From these two scores, a global preference score was calculated, which served as an indicator of global vs. local attention: the higher the score, the more globally oriented a person was. The results suggested that the Taiwanese in our sample perceived slightly more globally than the Czechs. The results, however, were not significant with small effect size, and therefore did not provide any strong evidence of cross-cultural differences such as those reported by McKone et al. [32]. The results

were more in favour of the findings of a preregistered study conducted by Hakim et al. [24], which did not detect any cultural differences in global processing between American, international Asian and Chinese samples, or the study by von Mühlénen et al. [60], which did not detect any differences between samples from the UK and India.

It is important to note that the differences in results may have been caused by the methods of administration and precise nature of the task. Hakim et al. [24] instructed the participants to identify target letters (E or H) in compound letters while stimuli were presented centrally. The respondents only responded whether the target letters were present on the global or local levels, without reporting the specific target, and stimuli were displayed until a response was given. Von Mühlénen et al. [60] asked the participants to identify a specific target (H or T) by pressing the respective key. The Navon task was assigned in combination with emotionally charged (happy, neutral, sad) images to affect the emotional state of the participant. Stimuli were presented until a response was given or for a maximum of 5 seconds. McKone et al. [32] presented the stimuli laterally to test hemispherical differences in global/local processing. We therefore declare that it would be premature to draw final conclusions on the issue of cross-cultural differences in global vs. local attention.

An interesting effect observed in the global and local reaction times should be noted. Although both groups were slightly quicker in responding to global tasks than local tasks, the reaction times of the Taiwanese group were, in both cases, approximately twice as long. This finding replicated the results of the CFT reported by Lacko [45] in samples of Czech and continental Chinese participants. Chinese participants were also significantly slower. Since the test instructions in both Czech and traditional Chinese included the instruction to solve the task “as quickly as possible”, such a large difference in reaction times should not be an indicator of method bias [50, 61] but more probably of the differences in response styles between both samples. These differences in speed of response might also be explained by the avoidance of risk-taking behaviour inherent to Confucian ethics [62], or the notion of “losing face” typical for some Asian cultures [63]. These assumptions should be tested in future research, for example, by manipulating individual/group administration of the task, or with the administrator persona (e.g. Would the perceived social status of the administrator influence the tendency of the participants not to make mistakes?).

Complex scenes

The second dimension in differences of perception, i.e. context sensitivity, was investigated by measuring eye-tracking patterns while complex real-world scenes were observed. Two types of real-world scenes were shown in which the number (one or two) of focal (perceptually salient) objects was changed. According to previous research [15, 36], we expected Czech participants to focus relatively more on focal objects (first fixations, number of fixations, fixation time) than the Taiwanese, and also, because of the expected holistic nature of eye-movement patterns of the Taiwanese, we assumed that they would make more transitions between various parts of the stimuli. Stimuli with one and two focal objects were analysed separately.

No significant cross-cultural differences were found in the percentage of first fixations on focal object(s). The results were consistent across both stimulus types. Both groups mostly first fixated on the focal object, which is consistent with previous findings [15, 23, 36] and suggests the prevalence of bottom-up perceptual processes soon after the stimulus is displayed. The early visual attention was mainly driven by the perceptual properties of the stimulus, and the subjects primarily fixated on highly salient objects [64].

In both the one and two focal object conditions, the Czech participants made significantly more fixations on the focal objects and spent less time fixating on the background than the

Taiwanese. In the case of stimuli with two focal objects, the Taiwanese made significantly more background fixations. These results agree with the assumption that analytic perceivers focus more on the focal object and its properties and that holistic perceivers focus relatively more on the background [1]. The Czechs also transitioned significantly more between both focal objects, which might again be an indicator of relatively higher focus on objects [1]. However, contrary to our expectations, no cross-cultural differences in focal object to background transitions were detected in either the one or two focal object conditions. As holistic perceivers, if the Taiwanese observed the image as a “whole”, we would expect them to make more transitions.

The results showed that the Czechs made more transitions between focal objects. The main eye-tracking metrics (number of fixations, fixation time) in this study replicated the results of studies conducted by Chua et al. [36] and Duan et al. [15] and demonstrated the expected higher focus of Czechs on focal objects (number of fixations) and of Taiwanese on backgrounds (fixation time). As mentioned by Rayner et al. [26], it is questionable whether the number of the points of interest in the scene affected the scanning patterns across cultures. Our results showed that the cross-cultural differences in scanning patterns were consistent for both stimuli with one and two focal objects.

Theoretical implications

The present study is one of few that have attempted to compare multiple components of cognitive styles within the framework of the general holistic–analytic model [1, 2]. It defines cognitive style as a bipolar dimension in which analytic perception is defined as rule-based, formally logical, field independent, with selective attention focused on salient objects and locally oriented, while the holistic pole is rather intuitive, dialectical, field dependent, sensitive to context, with attention focused on the “whole” and globally oriented. Two tasks were used to analyse cognitive style: hierarchical figures (global and local processing) and complex natural scenes (attention to object and background). Using linear regression, no significant relationships were found between the tasks, which is in line with other studies [8, 24] that used more methods to validate the analytic–holistic cognitive styles theory and found them unrelated.

The results raise questions of a) the validity of the concept of cognitive styles and b) its dichotomous nature. In terms of a), Cuneo et al. [65] tested the discriminant validity of methods for analytic–holistic style diagnostics and found that questionnaire methods overlapped with personality and that maximum performance methods (Group Embedded Figures Test) overlapped with intelligence. Further research should test the construct, concurrent and discriminant validity of cognitive styles, especially in relation to personality and intelligence. Some methods not based on maximum performance attempt to overcome this problem by using two independent tests: one for each of the opposing poles of cognitive styles. In terms of b), if the concept of cognitive styles is valid and non-overlapping with other constructs, its nature might be different from the possibly reductionist dichotomic analytic–holistic (or “East–West”) definition of the general holistic–analytic model. Kozhevnikov et al. [37] proposed an alternative hierarchical–ecological model of cognitive styles (see [Introduction](#)) that has the form of a hierarchical matrix in which cognitive style families are organized along levels of informational processing. According to this model, the different cognitive styles would not necessarily have to (cor)relate, because an environment might, for example, support the development of global processing (holistic characteristic) and focus on salient objects (analytic characteristic). This model might explain the lack of correlation between different methods of cognitive style analysis observed in this and some other studies [8, 24, 45]. Future research should therefore attempt to verify the hierarchical–ecological model [37] of cognitive styles

and specify the number of cognitive style families. Conducting research on the stability/flexibility of cognitive styles and investigating the developmental aspects (e.g. children of different ages) of cognitive style and its adaptive nature (e.g. research on expatriates during the process of cultural adaptation) is also suggested.

Limitations

This study carries some limitations. Most importantly, only student samples were used for this research. The potential differences in results obtained from student samples and the results from Czech and Taiwanese general population subgroups would be based on the adopted theoretical perspective. If we adopt the dichotomous approach of the general holistic–analytic model [1], which states that East is holistic and West is analytic, we would expect to find similar patterns in the similarities and differences between other Czech and Taiwanese subpopulations. We might also expect larger effect sizes if more diverse subpopulations (e.g. uneducated individuals, children, seniors) are compared. However, if we adopt the approach of the hierarchical–ecological model [37], we could expect substantially different patterns of global attention or context sensitivity in different subgroups, because these subgroups might mature and live in fundamentally different social and physical environments that require distinct ways of cognitive adaptation. Furthermore, a study by Waxman et al. [66] showed evidence of cross-culturally divergent developmental changes in attentional patterns. Our results, therefore, are not generally applicable to all citizens of the Czech Republic or Taiwan.

Potential differences in eye-tracking systems in the Czech Republic and Taiwan need to be mentioned among the limitations of our study. However, we gave special attention to this issue throughout all stages of the research to eliminate any possible confounding effects and assure full equivalence in measurement. Both eye-tracking systems were set to the same sampling frequency. Both eye-tracking systems also had similar spatial accuracy and precision [67]. The spatial accuracy threshold was the same for both measurements (max. 1° of visual angle), and the calibration error was the same in both samples (0.56° of visual angle). Fixation calculations were also conducted simultaneously for both datasets in Ogama software, and the ROIs were the same for both cultural groups. Only robust eye-tracking metrics (number of fixations, fixation time, transitions in ROIs) were calculated [49], and the ROI specification of the scenes was binary in character (figure vs. background). Therefore, the size of the stimuli (figures) used in this experiment was two levels higher (approx. 10° of visual angle) than the variability in accuracy of eye-tracking in the participants (approx. 0.1° of visual angle). Therefore, the interference in data caused by using two eye-tracking systems can be considered negligible in our research design.

Another point to consider is the nature of the task, as it might be a method factor that affects eye-movement patterns and potential cross-cultural differences in these patterns. As previously mentioned, the eye-movement task was an implicit, free-viewing task for evaluating the “aesthetic preferences” of each image. It should be noted that the eye-movement patterns might differ depending on the nature of the task, as demonstrated by Yarbus [68] in his seminal monograph. In his qualitative study, instructions were manipulated and the differences in eye-movement patterns were subsequently observed. Castelano et al. [69] found differences in aggregate eye-movement metrics depending on whether the observers searched for a target or memorized the stimuli. The need to consider the nature of the task while evaluating cross-cultural differences is also emphasized by Alotaibi et al. [16]. Greene et al. [70], however, demonstrated quantitatively with pattern classifiers that the task-related effects on scene viewing might be overrated, at least in the case of brief presentations of stimuli, when an observer’s gaze seems to be mostly driven by the saliency of various parts of the scene. Nevertheless, the

observed similarities and differences between both groups in eye-movements should not be generalized to other possible scene perception designs (e.g. passive viewing, visual search or recognition).

While some studies reported differences between Americans and Chinese [36] and Chinese and Africans in a free-viewing task [15], studies conducted by Rayner et al. [25] combined with a memory task showed negative results. Similarly, no cross-cultural differences were found in a change-blindness experiment performed by Masuda et al. [34]. Future eye-tracking research exploring the perception of complex scenes should attempt to combine several tasks (e.g. free-viewing, visual searches, flicker-tasks).

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Appendix VI

Study VI



OPEN

Cross-cultural analysis of eye-movement patterns in visual scene perception: a comparison of seven cultural samples

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This eye-tracking research investigates cross-cultural similarities and differences in visual attention in complex scenes free-viewing perception. The study utilizes 70 real-world photos with one or two focal objects as stimulus materials. The study examines the amount of time spent on focal objects, saccadic lengths, temporal changes in saccadic lengths and factors that influence these metrics. Data were collected between 2020 and 2022 from seven cultural samples in Africa, East Asia, Europe, and the Near East ($N = 408$). Contrary to initial hypotheses, the findings challenge the expected order of countries in terms of attention toward objects. Participants from Taiwan, assumed to exhibit holistic patterns, displayed the most holistic viewing pattern. Surprisingly, participants from Germany and Czechia did not significantly differ from those in Taiwan. Furthermore, participants from Ghana and Türkiye, expected to be moderate, showed the most analytic pattern. This challenges preconceived notions and contributes to understanding patterns of scene perception in underrepresented countries. Additional analyses explored the relationship between number and size of focal objects and dwell time, as well as the potential influence of sociodemographic variables, on dwell time.

Keywords Eye-tracking, Scene perception, Cross-cultural research, Holistic and analytic perception

Cross-cultural research has yielded valuable insights into the systematic variations in perceptual and cognitive processes across nations and cultural groups. This rich area of research encompasses a diverse range of cognitive processes, such as object categorization, attitudes toward contradictions, object-background separation, selective attention in complex scenes, global-local processing, and sensitivity to visual field changes¹.

Expanding on this foundation, a theory of holistic and analytic cognition has been formulated² which posits the existence of two distinct modes of cognitive processing: holistic and analytic cognition. It suggests that individuals tend to engage predominantly in one of these styles, shaping their cognitive processing. Holistic thinkers, compared to their analytic counterparts, rely more on intuitive strategies rather than rigid rules in object categorization^{3,4}, embrace dialectical thinking over formal logic, face challenges in object-background differentiation⁵, prioritize the contextual relationships between objects over salient focal objects and attributes⁶, exhibit a preference for global over local features⁷, demonstrate higher sensitivity to contextual changes rather

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than focal object changes⁸, and lower central fixation bias⁹. Most of the research mentioned above concludes that analytic cognitive mode is more typical for Western countries (USA, Western Europe) and holistic mode of perception is more typical for Asian countries.

Drawing inspiration from this theory, our current research focuses on one specific aspect of visual perception: selective attention to objects and their surrounding context when perceiving complex natural scenes, also referred to as context sensitivity or attention to the field¹⁰. Within this framework, “analytic” cognition has been linked to an object-centred attentional mode: people attend to focal objects, classify them via rule-based categories, and explain events by reference to internal object properties. By contrast, “holistic” cognition emphasises field-wide information; attention is distributed across background elements and inter-object relations, and reasoning is guided by similarity and contextual fit rather than abstract rules². Several previous studies have explored cross-cultural differences in context sensitivity using natural scenes and eye-tracking techniques within the free-viewing paradigm^{11–13}. More specifically, some researchers have discovered distinctive patterns of eye movements between Chinese and North American participants¹¹ and between Chinese and African participants¹², or between Taiwanese and Czech participants⁶. In this context, an analytic pattern empirically manifests as longer dwell time on focal objects and correspondingly shorter saccades within the first seconds of viewing, whereas a holistic pattern is characterised by broader scan paths and more time allocated to the background¹¹.

However, some studies failed to replicate or even contradicted the theory of holistic and analytic cognition. For instance, Rayner et al.¹⁴ recorded eye movements across six information-processing tasks and found no reliable East–West divergence in attention to objects versus backgrounds. Using the original Chua et al.¹¹ materials, Evans et al.¹³ likewise reported null cultural effects between American and Chinese in eye-movements and scene recognition. Furthermore, Rayner et al.¹⁵ showed that American and Chinese observers looked equally quickly at the “weird” components of manipulated scenes. Finally, Mielle et al.¹⁶ masked central vision dynamically during an animal-search task and found identical oculomotor strategies in Western and Eastern participants. Given the contradictory evidence on the systematic cultural differences in perception and cognition, the research in this field is far from concluded.

Despite the existing body of research, there are still some gaps that need to be addressed. Most existing eye-tracking studies contrast a single “Western” sample (typically the United States) with a single “East-Asian” sample (Japan, China, or Korea). This dichotomy leaves unanswered whether the purported holistic–analytic split is categorical or graded, and whether it covaries with specific socio-ecological variables such as urbanisation, education system, or relational mobility^{17–19}. We therefore adopt a gradient view: societies positioned closer to the historical core of Western Europe on indices of individualism, “Book religions”, and alphabetic literacy are expected to show the most object-focused (analytic) gaze, whereas societies further away on those dimensions should exhibit progressively more context-focused (holistic) patterns. Taiwan represents the East-Asian pole because its Confucian heritage, logographic writing system, and collectivistic value profile mirror those of the cultures in which holistic gaze patterns were first documented^{10,11}.

Furthermore, the limited sample diversity and the predominant focus on Western (read Anglo-Saxon, associated with analytic cognition) and Eastern countries (read East-Asian, associated with holistic cognition) when defining the theory of holistic and analytic cognition present obstacles to its potential advancement. To expand the body of knowledge on scene perception beyond the commonly compared countries, we gathered data from three European countries (Germany, Bulgaria, Czechia), two samples from a country on the border between Europe and Asia (Türkiye), an African country (Ghana), and one East-Asian country (Taiwan). The decision to collect two separate samples from Türkiye aimed not only to examine cross-country differences but also to explore within-country differences in the relatively largest and most diverse country in the sample. To achieve this, we deliberately gathered data from participants born and raised in both the Western and Eastern regions of Türkiye.

One of the central questions was how to determine the rank of the countries on the holistic-analytic spectrum prior to delving into the data, especially when faced with a lack of robust empirical evidence to substantiate the formulation of our hypotheses, at least in some of the comparisons (e.g. between Türkiye and Ghana). Based on the previous research, we expected the participants from Germany (a representative of the Western country) to be the most analytic¹¹, followed by participants from Czechia and Bulgaria (post-communist Europe)²⁰. On the other hand, Taiwan is expected to be the most holistic country. Participants from Ghana and Türkiye should fall between these countries¹². Finally, we expected no differences between the participants from Eastern Türkiye compared to their Western counterparts²¹, but decided to test them.

In the current research, we focus on cross-cultural similarities and differences in one of the aspects of visual perception - attention to (focal) objects and background - using complex visual scenes (naturalistic photographs). The main variables of interest (dependent variables) were the amount of time spent on objects (focal object dwell time; calculated as a sum of fixation durations) and saccadic length (calculated in pixels). Dwell time reflects how long a viewer attends to focal objects vs. contextual elements, with cultural differences between object-oriented (analytic) and context-sensitive (holistic) styles. Saccadic length and its temporal changes provides insight into whether a viewer is making smaller, detail-focused movements or larger, more context-focused shifts²². These measures are frequently used in eye-tracking studies of context sensitivity^{6,11,21,23}. We were also interested in the temporal changes in saccadic lengths during the stimulus presentation, and in factors that might have influenced the object-oriented attention. Therefore, we formulated several assumptions related to differences in eye-movements across cultural samples.

The hypotheses are categorized as major or minor (H_{ma} , H_{mi}). First, statistical equivalence of both Turkish samples in the dependent variables (dwell time on focal objects, saccadic length) was tested using a TOST procedure (two one-sided t-tests) proposed by Lakens²⁴. When statistical equivalence is not achieved, merging the samples and analyzing them as one group is not advisable. As already mentioned, we expected the same patterns of eye-movements in both Turkish samples ($H_{mi}1$).

Next, we tested for differences in the average dwell time on focal objects (main hypothesis $H_{ma}1$) and the average saccadic length ($H_{ma}2$). Analytic perceivers should according to the theory attend relatively more to the focal objects, therefore, the average dwell time on objects should be longer. Moreover, analytic perceivers should more prevalently use focal visual scanning patterns that are typical with relatively longer fixations and relatively shorter lengths of saccades in the first few seconds after the stimulus onset²². Therefore, we expected the following order of countries in the average dwell on focal objects: Taiwan < Ghana < Türkiye-East < Türkiye-West < Bulgaria < Czechia < Germany. The opposite pattern was expected in the saccadic length (Taiwan > Ghana > Türkiye-East > Türkiye-West > Bulgaria > Czechia > Germany).

Next, we tried to test several minor hypotheses. Follet et al.²² demonstrated a significant drop in saccadic length after three seconds from the stimulus onset when free-viewing complex visual scenes. This effect should be independent from the content of the scene. We have no specific cross-cultural hypothesis regarding this, but we would expect to replicate the drop in saccadic length in our study ($H_{mi}2$).

In the next set of hypotheses, we wanted to explore potential effects of stimulus characteristics, namely (a) the number of focal objects, and (b) the relative size of focal objects, on the average dwell time. The manipulation with the number of focal objects tests whether increasing object load demands additional visual processing: when two independent items are present, viewers must individuate, compare, and encode each one in turn, which should prolong the cumulative time their gaze remains within the object ROIs. We therefore expect that, as the number of focal objects (1 vs. 2) rises ($H_{mi}3$) and as their relative size increases ($H_{mi}4$), participants across countries will display longer mean dwell time on the focal objects.

The last exploratory hypothesis tries to investigate whether individual sociodemographic factors such as gender, age, or socioeconomic status²⁵ have some kind of effect on dwell time or saccadic length during free-viewing of complex visual scenes ($H_{mi}5$) as suggested by some previous research in the field²⁶.

Methods

Research ethics

The Research Ethics Committee of Masaryk University reviewed the application to conduct the research project and has approved this project (Proposal No.: 0257/2018) to be conducted on 13 March 2019. Nature of methods used and their administration was performed in accordance with the relevant guidelines and regulations of Masaryk University and national laws. Informed consent was obtained in writing from all participants.

Use of LLMs

Chat GPT (v. 4O, <https://chatgpt.com/>) LLM was used for English proofreading of all sections of the text, and for polishing the analytic code.

Materials

Real-world scenes

The stimulus materials consisted of complex scenes - real-world photos. The scenes were obtained from the online databases containing free-to-use for non-commercial purposes license photos (CC BY-NC-SA and more permissive licenses). We set several pre-selection criteria of the photos: (a) the image should contain one or two focal objects, (b) there should be no people or animals present in the image, (c) there should be no components of the image that would reveal the exact location, where the image was taken, present in the picture (no commonly known landmarks, no writing).

To verify that the scenes fit our criteria, we conducted a qualitative evaluation of the scenes. The preselected images were sent to four independent evaluators (members of the research team) from countries involved in this research. The evaluators were given the definitions of a focal object (“*The main figure(s) or object(s) in the picture. It is salient and can be in the foreground.*”) and background (“*The part of a picture that forms a setting for the main figure(s) or object(s), or appears furthest from the viewer.*”) and asked to: (a) indicate how many objects they identify in the image, (b) name those objects. Minimum of three out of four evaluators had to agree in the evaluated criteria. Scenes that passed this qualitative evaluation (i.e. they had the same number of objects, same components of the image are perceived as objects) were kept in the test battery, other pictures were discarded.

In total, 98 scenes out of the original 160 were retained after the qualitative evaluation. In the next step, we unified the size of each image and added a black frame occupying 10% of the entire stimulus (see Fig. 1; size without the frame: 922 × 692 px; size with the frame: 1024 × 768 px). This was done due to the lower accuracy of eye-tracking systems in the display periphery²⁷. Subsequently, for each stimulus, we defined the surface occupied by focal objects and computed an index of relative focal object size that was used both for further selection of stimuli and later on in the statistical analysis. In the next step, we ranked the images by the relative size of the focal object (min = 1%, max = 40%). Images with extremely small or large portions occupied by focal object(s) were discarded. The resulting range of relative focal object size was between 5% and 28%. This variable was transformed to z-score. Based on z-scores, the stimuli were placed in one of three categories: stimuli with small ($N=12$), medium ($N=43$), and large ($N=15$) focal objects (cut-off points at z-score -1 and 1). These 70 stimuli comprised the test stimuli (trials).

Each trial was presented for four seconds and was preceded by a central fixation cross displayed until the moment a participant fixated on it. The participants were instructed to “*view a series of pictures*” and evaluate “*how much they liked each picture*” on a scale ranging from 1 to 5 (1—very good, 5—very poor). The task of rating scene likability was included solely to maintain participant engagement and prevent boredom effects, contributing to enhanced attention and motivation during the experimental session^{11,12,22}.

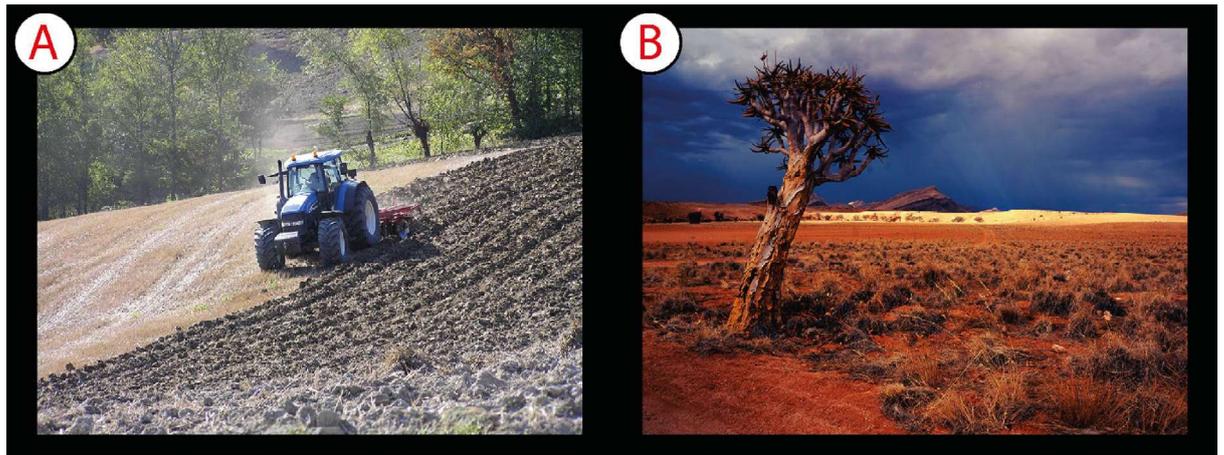


Fig. 1. Sample stimuli with (A) man-made and (B) natural focal objects.

Sociodemographic questionnaire

Apart from the scenes, sociodemographic data were collected by a questionnaire. Data on sex, age, nationality, marital status, number of siblings, mother tongue, socioeconomic status, and other variables were collected. This research was part of a larger test battery and not all of the variables collected were used in this research. For a full list of variables collected, including their coding, please see Supplement. All materials were translated by two independent translators using a back-translation method. The translation process for each language was overseen by native members of the research team from the respective countries, all of whom were well-acquainted with the research objectives.

Apparatus and procedure

The sociodemographic data were collected using the software Hypothesis^{28,29} running on Google Chrome web browser between February 2020 and April 2022. The eye-tracking data were collected using SMI RED 250 mobile in all countries except for Taiwan. In Taiwan, an EyeLink 1000 was used. The sampling frequency was set to 250 Hz with 9-point calibration. The desired accuracy threshold of calibration was set to 1° of visual angle. The selection of eye-tracking systems was guided by their specifications and performance parameters to guarantee methodological comparability of the recorded data. The SMI RED 250 mobile is specified at 0.4° accuracy and 0.03° RMS precision by the manufacturer³⁰, whereas the EyeLink 1000 is specified at $\leq 0.15^\circ$ (typical 0.25–0.50°) accuracy and 0.01° RMS precision³¹. Independent benchmark studies report mean empirical accuracies of ~ 0.5 – 0.9° for the SMI RED 250 under 9-point calibration³² and $\sim 0.6^\circ$ for the EyeLink 1000 in a 49-target fixation grid³³. These values confirm that both systems meet the $\leq 1^\circ$ criterion recommended for dispersion-based scene-perception research³⁴. Both systems can be considered relatively accurate and precise, and also comparable in both parameters.

However, we conducted the task even with participants with lower accuracy to make the entire experimental procedure constant for all participants (the same order of tests in the test battery). In all countries, stimulus material was presented on 22" LCD monitors set to 60 Hz refresh rate and 1024 × 768 resolution). Participants viewed the stimuli using chin-rest positioned approximately 60 cm away from the monitor. The laboratory setup, data collection, as well as all the subsequent phases of data cleaning and analysis adhere to the guidelines for eye-tracking studies by Dunn et al.³⁵.

Data processing and cleaning

Sampling plan

The sampling plan and participant exclusion criteria for this study were pre-registered (see Data availability section). As part of a larger test battery, we collected data from university students across 7 countries (Ghana, Taiwan, Armenia, Bulgaria, Türkiye, Czechia, and Germany) in 8 independent samples (for contrast, Turkish participants born in Eastern and Western regions of the country were collected). Sample size was determined based on a priori power analysis with specifying small-to-medium effect size (Cohens' $f=0.18$). Using common settings ($\alpha=0.05$, $\beta=0.20$) in G*Power (v3.1.9.7)³⁶ for One-Way ANOVA with 8 groups resulted in total 456 participants, i.e. 57 participants per a group (Noncentrality parameter $\lambda=14.77$, Critical $F=2.03$, Numerator $df=7$, Denominator $df=448$). Counting with a certain data loss that is quite common in eye-tracking studies we aimed to collect 60–70 participants per cultural group. Due to the low data quality of a sample collected in Armenia, the number of participants would drop far below the desired number (to only 15 participants out of 58 collected). All the data cleaning and sample information below are therefore reported *without* the Armenian sample (deviation from the pre-registration described in the Supplement).

Due to the fact that the number of groups changed, and the final number of participants was below the planned number, we calculated a post-hoc sensitivity analysis for the statistical tests that were used in this study. ANOVA ($\alpha=0.05$, $\beta=0.20$) for 7 groups and 408 participants should be able to detect small-to-medium effect ($2=0.03$). Post-hoc t-tests with the same settings should detect Hedges's medium to large effect ($g=0.59$)³⁷.

TOST procedure²⁴ used for the tests of equivalence between both Turkish samples was able to detect medium effect ($d = 0.40$).

Data processing—raw data

Since data collection was conducted using multiple eye-tracking systems and due to the incompatibility of their software (different native fixation detection algorithms, impossibility to import data gathered with one eye-tracker into another), we employed a meticulous data processing procedure described below. This procedure should eliminate or at least minimize any method-related artifacts. Additionally, to assure good data quality, several data quality checks were performed and data not meeting a sufficient quality were discarded from the further analysis. For a full list of discarded participants and reasons for their removal see the Supplement.

In the first step, data were exported from *SMI BeGaze* and *SR Research Data Viewer*. Also, the first phase of data cleaning was performed. We discarded all participants with incomplete administration, low accuracy, administration with incorrect sampling frequency, or impossibly short experiment duration. Thirty-two participants were discarded in this phase. Subsequently, we prepared the raw data to be imported to Ogama software (v5.0.1)³⁸. This included mainly changing file names, relabeling of trial names and IDs, removal of duplicate timestamps, relabeling of participant IDs, and reordering columns. The R-codes for these transformations are available in the OSF repository.

Data processing—Ogama

In Ogama, the ROIs were drawn for each test trial (Fig. 2). ROIs are defined around the contours of the focal objects. Both the picture slides and the ROI coordinates exported from Ogama are available at the OSF repository. Subsequently to the definition of ROIs, the eye-movement metrics were calculated. Ogama uses an I-DT dispersion-type algorithm for fixation detection³⁹. We used the settings recommended for 250 Hz data by Popelka⁴⁰: maximum distance of 15 px, minimum number of 20 samples, size of 31 px for the fixation detection ring, automated elimination of first fixation, and no merging of consecutive fixations. The following metrics were exported for each participant and trial: trial duration, data loss, fixation count (trial and each ROI), fixation duration (dtto), and saccade distance (dtto). Ogama exports saccade length in screen-pixel units, and we recalculated the saccade length to more commonly used degrees of visual angle. All sites used identical 22'' monitors (1024 × 768) viewed from a chin-rest-fixed 60 cm distance. Under this geometry 1 pixel ≈ 0.042° of visual angle, so each pixel value was multiplied by 0.042 to yield saccade length in degrees.

Data processing—quality check after fixation calculation

After the ROI definition, fixation calculation, and export of eye-movement metrics we conducted a second phase of data cleaning (pre-registered). Trials were excluded if they met the following conditions: (1) the percentage of data loss was greater than 20%, which equated to more than 800 ms of lost data, based on the guidelines proposed by Komogortsev et al.⁴¹; or (2) the number of fixations was less than five, as recommended by Follet et al.²². The average number of trials excluded in this fashion varied between 4.66% in Czechia and 15.90% in Ghana. Furthermore, if a participant had more than 20% (i.e., 15 or more) of trials excluded based on these criteria, they were excluded from subsequent analyses to ensure data integrity. Forty additional participants were deleted in this phase. The number of *missing (deleted) trials* after the removal of participants was 4.37% and the *mean data loss as exported directly from Ogama* was 3.05% across all participants with very similar values in all countries (minimum of 2.71% in Türkiye-West and maximum of 3.82% in Taiwan). Both numbers indicate high data quality after the data cleaning procedure. As an additional quality control, we also computed a median of intersample angular distances precision^{34,42,43} for every trial, fixation, and participant, and compared these across countries using a mixed-effects model (see the Supplement). The S2S seems to be acceptable to make meaningful comparisons across cultural samples⁴⁴.

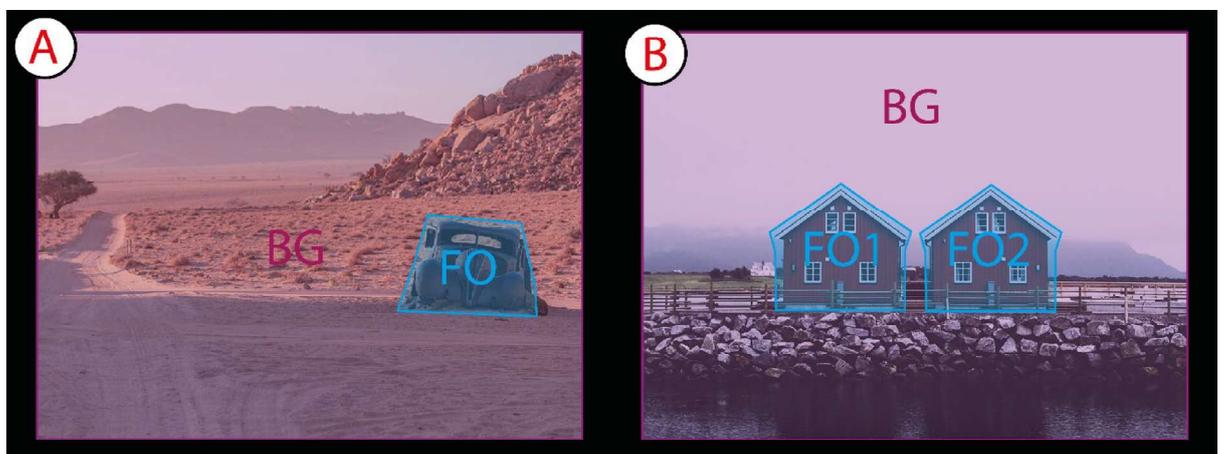


Fig. 2. ROIs with (A) one and (B) two focal objects.

Tests of assumptions and equivalence

Assumptions of ANOVA (normality, homoscedasticity, sphericity) were tested before each of the presented analyses. In the case of violation of these assumptions, a robust variant of the statistical test was calculated (Welch's ANOVA, bootstrap heteroscedastic ANOVA for trimmed means, Games-Howell post-hoc). Results of assumptions testing can be found in the Supplement. To test for equivalence of both Turkish samples, we used TOST²⁴ with medium equivalence bounds of $d=0.40$. The procedure allows - unlike null hypothesis significance testing - to interpret evidence in favor of null hypotheses (in our case, in favor of equivalence of the two cultural groups).

Data were analyzed using R, version 4.1.2⁴⁵ and the packages *afex*, *effsize*⁴⁶, *ggforce*, *ggdist*⁴⁷, *gghalves*, *lme4*⁴⁸, *lsr*, *mclust*⁴⁹, *performance*⁵⁰, *psych*⁵¹, *rstatix*, *TOSTER*⁵², and *WRS2*⁵³.

Research sample

After the data cleaning procedure, 408 cases were retained in the research sample (Table 1). The minimum size of a subsample is 42 (Ghana and Türkiye West), the maximum is 92 (Czechia). The percentage of females varies between 32 in Türkiye East to 66 in Taiwan. Regarding the age of participants, the mean age of participants varies around 21–22 years, with the exception of Germany that is represented by marginally older participants (25 years average). The total sample size is slightly below the desired sample size (see the *Sampling plan* section), which is primarily caused by lower number of participants retained in subsamples from Ghana and Türkiye West).

Results

Equivalence of Turkish samples

To be able to determine, whether or not both Turkish samples can be considered equivalent ($H_{mi}1$), we performed the TOST with set $d=0.40$ bounds²⁴. If found equivalent, the samples could be grouped and analyzed together (see the Supplement for details on the equivalence tests). Tests were computed for both main dependent variables, the average dwell on focal objects and the saccadic length. Regarding the mean dwell time on focal objects, there was no significant difference between the two Turkish samples, $t(79.8)=0.93$, $p=.358$, *mean difference* = 56.52; *Hedges's g* = 0.19, $CI_{95\%}$ [-0.15, 0.53]. However, the TOST suggests that the groups are not equivalent; $t(79.8)=0.92$, $p=.82$. Regarding the mean saccadic length, no significant difference was found between the two Turkish samples, $t(95.6)=-1.69$, $p=.094$, *mean difference* = -9.71; *Hedges's g* = -0.34, $CI_{95\%}$ [-0.66, -0.00] and the samples were non-equivalent, $t(95.6)=-1.60$, $p=.950$.

In summary, the testing of sample equivalence in the two dependent variables shows no evidence of equivalence of neither the samples from Türkiye. This means that the grouping should not be performed and the samples will be further compared individually.

Dwell time on focal objects

One-way ANOVA with cultural group as an independent variable and average dwell on focal objects as a dependent variable was conducted to identify potential differences in dwell across cultural groups ($H_{ma}1$; Fig. 3). Effect of culture was significant, $F(6, 401)=12.77$, $p<.001$, with large effect size $\omega^2=0.15$, $CI_{95\%}$ [0.09, 1.00]. The mean focal object dwell time varied between 1,895 ms ($SD=304$, $SE=46$) in Ghana and 1,528 ms ($SD=281$, $SE=34$) in Taiwan. When inspected in the direction from longest to shortest average dwell, the first significant difference can be observed between Ghana and Czechia (*mean difference* = 247 ms, $p<.001$; *Hedges's g* = -0.92, $CI_{95\%}$ [-1.30, -0.54]). Inspecting the differences in the opposite direction, the first significant difference can be found between Taiwan and Bulgaria (*mean difference* = 205 ms, $p=.001$; *Hedges's g* = 0.75, $CI_{95\%}$ [0.38, 1.11]). Full descriptives and all post-hoc tests are reported in the Supplement.

To further explore patterns of attention to object vs. attention to the background, we performed a series of t-tests on the size of differences between dwell time on objects and background in each of the cultural samples (Table 2). Each pairwise comparison is statistically significant. Yet, in the case of Taiwan, the effect size is notably lower (medium) compared to the other subsamples (high).

Saccadic length

To analyze potential cross-cultural variations in saccadic length ($H_{ma}2$; Fig. 4), we conducted a Welch one-way ANOVA. The effect of culture was significant, $F(6, 163.2)=7.43$, $p<.001$, with large effect size $\omega^2=0.18$, $CI_{95\%}$ [0.08, 1.00]. The mean saccadic length varied between 7.06° ($SD=1.09$, $SE=0.17$) in Ghana and 8.31° in Taiwan

Subsample	N	% of females	Age: Mean (SD)	Socioeconomic status: % of lower/middle/upper
Bulgaria	56	50	21.7 (2.07)	7/79/14
Czechia	92	65	21.98 (2.04)	13/72/15
Germany	54	59	25.67 (5.10)	6/63/31
Ghana	42	50	21.52 (1.09)	24/62/14
Taiwan	65	66	21.97 (2.35)	6/46/48
Türkiye East	57	32	22.54 (1.88)	18/79/3
Türkiye West	42	33	22.14 (1.94)	14/72/14
Entire sample	408	53	22.48 (2.90)	12/67/21

Table 1. Sample characteristics.

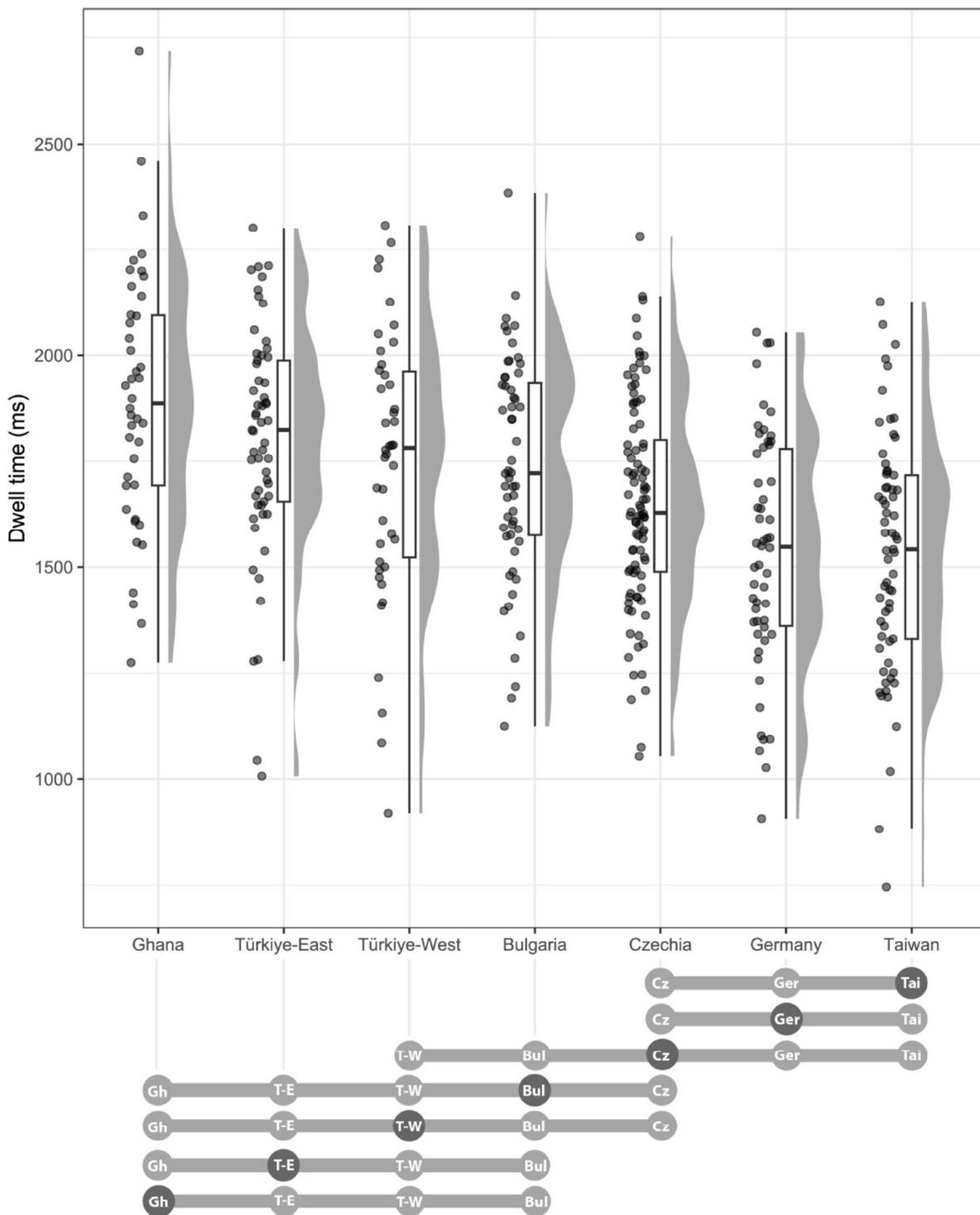


Fig. 3. Violin plots show the full distribution of participant-level mean dwell time on the focal-object ROIs, aggregated across all trials. The embedded box-and-whisker elements mark the median, the inter-quartile range, and $1.5 \times$ IQR limits; black dots are individual participants. Under the main plot, circles labelled with two-letter country codes are linked by grey bars whenever a post-hoc test found no significant difference between the connected pair. The darker circle in each row is the reference country for that particular set of comparisons.

Subsample	Dwell FO: mean (SD)	Dwell BG: mean (SD)	Mean diff*	p_{holm}	Hedges's g [$CI_{95\%}$]
Ghana	1895 (304)	1000 (187)	895	<0.001	1.95 [1.43, 2.46]
Türkiye East	1800 (272)	940 (224)	860	<0.001	1.97 [1.52, 2.41]
Türkiye West	1743 (320)	919 (174)	824	<0.001	2.11 [1.56, 2.64]
Bulgaria	1734 (263)	1097 (161)	637	<0.001	1.79 [1.36, 2.21]
Czechia	1648 (247)	1088 (200)	560	<0.001	1.51 [1.21, 1.80]
Germany	1533 (276)	1078 (214)	455	<0.001	1.32 [0.96, 1.68]
Taiwan	1528 (281)	1306 (261)	222	<0.001	0.44 [0.19, 0.69]

Table 2. Differences in dwell time on focal object (FO) and background (BG) by culture (in ms).

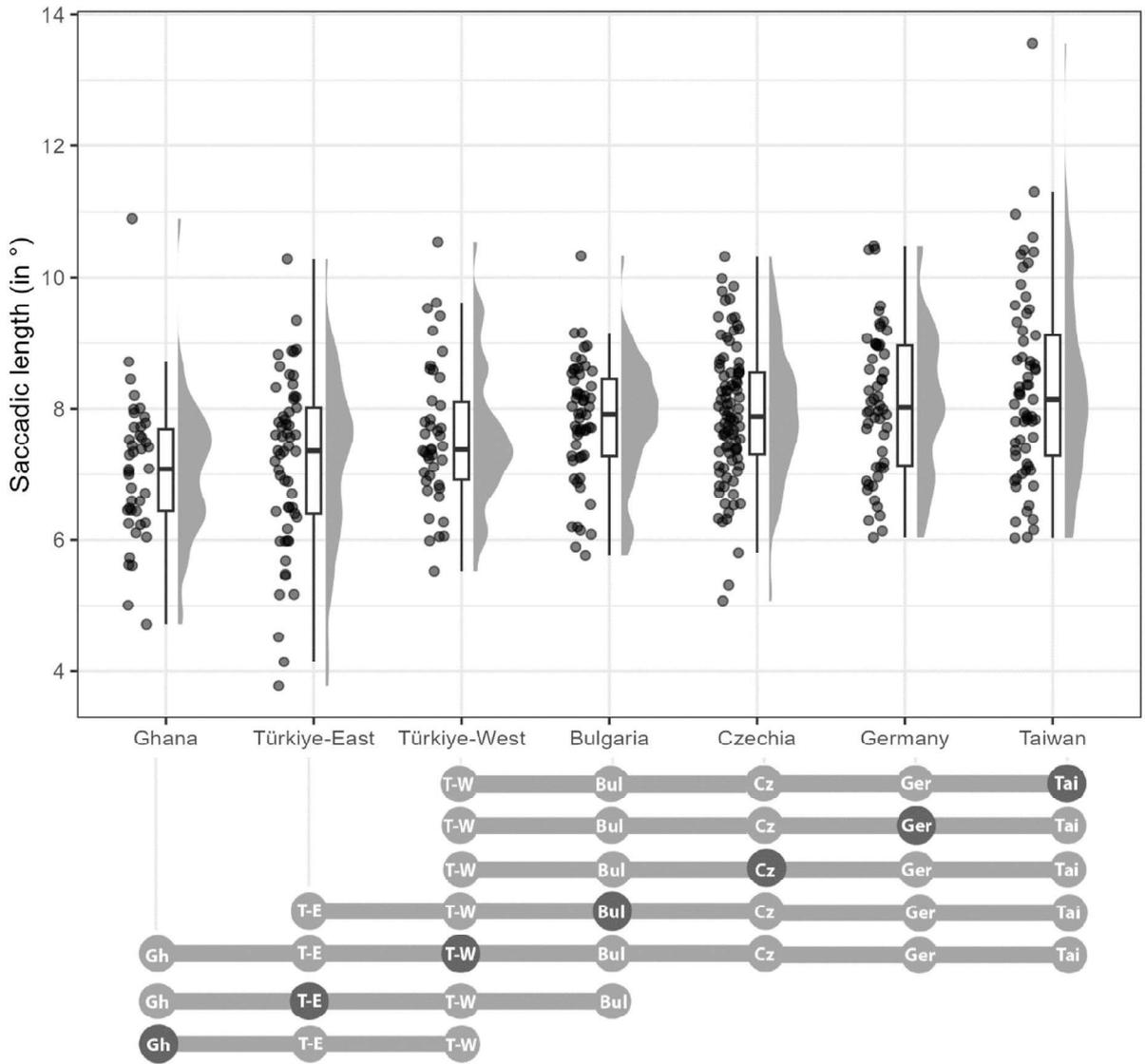


Fig. 4. Layout and symbols follow Fig. 3, but the dependent variable is participant-level mean saccadic length expressed in degrees of visual angle.

($SD=1.45$, $SE=0.18$). When inspected in the direction from shortest to longest mean saccadic length, the first significant difference can be found between Ghana and Bulgaria ($mean\ difference=0.75^\circ$, $p=.001$; $Hedges's\ g=0.81$, $CI_{95\%}$ [0.43, 1.18]). When inspecting in the opposite direction, the first significant difference can be found between participants from Taiwan and Türkiye East ($mean\ difference=0.72^\circ$, $p=.001$; $Hedges's\ g=0.44$, $CI_{95\%}$ [0.44, 1.17]). Full descriptives and all post-hoc tests are reported in the Supplement.

Temporal saccadic length changes

To replicate the findings of Follet et al.²² that, using almost identical research design, identified a drop in saccadic length three seconds after the stimulus onset, we calculated mean saccadic lengths for each of four seconds of stimulus presentation ($H_{mi}2$). At the aggregate level, the mean saccadic length did not show the expected pattern, but fluctuated from 7.44° ($SD=1.48$) in Second 1, through 7.86° ($SD=1.50$) in Second 2 and 7.61° in Second 3 ($SD=1.60$), to 8.07° ($SD=1.56$) in Second 4. The results of robust (bootstrapped, with 0.2 trimmed means) repeated measures ANOVA showed a significant main effect of time interval after stimulus onset $F(3, 404) = 18.03$, $p < .001$, $\xi^2 = 0.22$. All differences between individual levels were significant at alpha 0.05, except of saccadic length in Second 1 and 3, $p = .140$, *Hedges's g* = -0.18 , $CI_{95\%}$ [$-0.28, -0.09$] and in Second 2 and 4, $p = .060$, *Hedges's g* = -0.25 , $CI_{95\%}$ [$-0.35, -0.15$]. For full results see the Supplement. This pattern of fluctuations in saccadic length was similar at the level of each individual cultural group (Fig. 5).

Effects of stimulus characteristics on dwell time

In the next step, we explored cross-cultural differences in dwell time on focal objects based on the characteristics of stimuli. More specifically, we were interested in the effects of number of focal objects and their relative size (percentage of stimulus occupied by focal object).

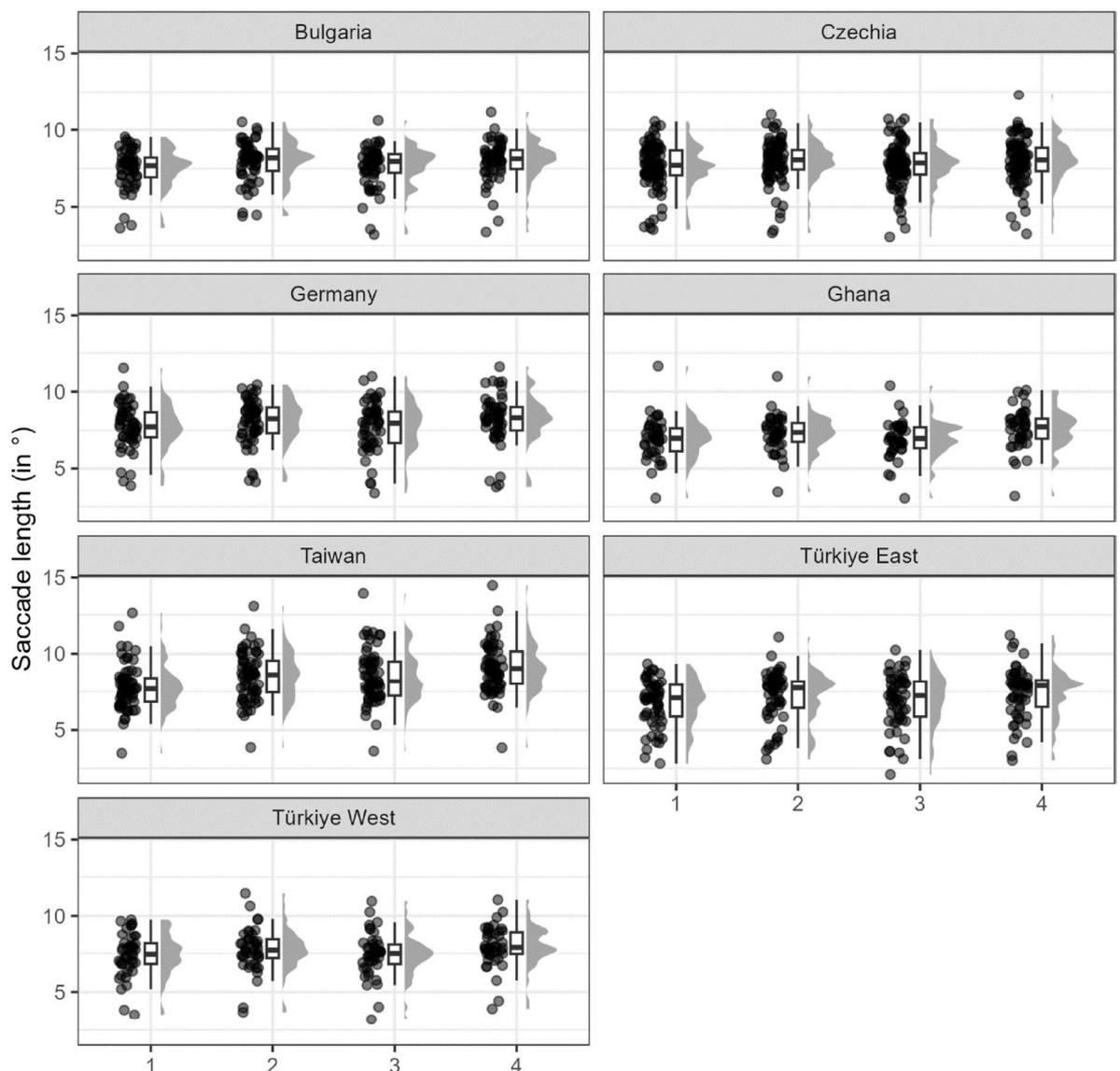


Fig. 5. Temporal changes in saccadic length across cultural samples. Each panel depicts one cultural sample. The x-axis divides the 4-s presentation interval into four successive 1-s bins (1 = 0–1 s, ..., 4 = 3–4 s). Within each bin, violin/box plots display the distribution of participant-level mean saccade amplitude.

Subsample	Dwell 1 FO: mean (SD)	Dwell 2 FO: mean (SD)	Mean diff*	P_{holm}	Hedges's g [$CI_{95\%}$]
Bulgaria	1724 (261)	1778 (340)	-54	0.345	-0.24 [-0.51, 0.02]
Czechia	1654 (251)	1622 (283)	32	0.414	0.18 [-0.03, 0.38]
Germany	1541 (274)	1497 (333)	44	0.447	0.23 [-0.04, 0.50]
Ghana	1904 (313)	1854 (325)	50	0.472	0.23 [-0.07, 0.53]
Taiwan	1553 (293)	1423 (281)	130	0.011	0.67 [0.40, 0.94]
Türkiye East	1824 (292)	1693 (288)	131	0.017	0.48 [0.21, 0.75]
Türkiye West	1772 (330)	1618 (323)	154	0.034	0.79 [0.45, 1.13]

Table 3. Focal object dwell time by culture - stimuli with one and two focal objects (in ms).

Effect of number of focal objects

Overall, the focal object dwell time was higher on stimuli with one focal object ($H_{mi}3$); $mean = 1694$ ms, $SD = 305$) compared to stimuli with two focal objects ($mean = 1628$, $SD = 333$). The difference was significant, $t(407) = 6.14$, $p < .001$; Hedges's $g = 0.30$, $CI_{95\%} [0.20, 0.40]$. At the cultural level (Table 3), the differences were significant in the case of Taiwan and both Turkish samples that exhibited longer dwell time on objects in the case of stimuli with one focal object compared to stimuli with two objects.

Effect of relative size of focal object

Furthermore, we conducted an analysis of effects of relative focal object sizes on dwell time ($H_{mi}4$). Across all samples, there is an apparent trend that the dwell time on objects increases together with their relative size. Focal object dwell time in trials with small objects ($mean = 1523$, $SD = 316$) was significantly shorter than in trials with medium ($mean = 1686$, $SD = 309$), $t(407) = -15.33$, $p < .001$, Hedges's $g = -0.76$, $CI_{95\%} [-0.87, -0.65]$, and large objects ($mean = 1800$, $SD = 350$), $t(407) = -21.27$, $p < .001$, Hedges's $g = -1.05$, $CI_{95\%} [-1.17, -0.93]$. The differences between trials with medium and large objects were also significant, $t(407) = -12.13$, $p < .001$, Hedges's $g = -0.60$, $CI_{95\%} [-0.70, -0.49]$. The same pattern is observable at the level of individual countries (see Supplement for all descriptives and t-tests).

Effects of sociodemographic variables

To determine whether the inclusion of sociodemographic variables improves the model fit ($H_{mi}5$), we included gender, age, and socioeconomic status as covariates of cultural group, and dwell time on focal objects, resp. saccadic length as dependent variables. Subsequently, we performed likelihood ratio tests of the nested regression models. The inclusion of covariates did not improve the model neither in the case of dwell, $\chi^2(5) = 379,530$, $p = .419$, nor in the case of saccadic length $\chi^2(5) = 4059.4$, $p = .372$, none of the covariates was significant. Corresponding AIC and BIC values of the reported models are in the Supplement.

Discussion

In this paper, we present results of possibly the largest cross-cultural study on perception of complex visual scenes, in both the number of cultural samples and overall sample size. Our findings aim to expand the body of research on holistic and analytic cognition beyond the WEIRD samples. In line with the recent findings by Uskul et al.⁵⁴, our findings contradict the idea that while the “Western” samples are characteristic with analytic perception while the “Eastern” should perceive holistically. Much more complicated patterns of cultural differences emerge when we focus on characteristics of eye-movements such as dwell time on focal objects and background and saccadic length. Our results, therefore, support the idea that a much more differentiated approach to research on cross-cultural specifics of perception and cognition is needed. The insights gained from this study might enable researchers to formulate more refined and context-specific hypotheses in future investigations, thereby advancing the field's knowledge base.

Most notably, the main hypotheses ($H_{mi}1$, $H_{mi}2$) that assumed a specific order of the countries regarding the attention to objects^{11,12} were not fully confirmed in the presented study. Eventough, participants from Taiwan exhibited the most holistic pattern of scene viewing having the shortest average dwell time on focal objects and the longest average saccadic length suggesting relatively highest proportion of ambient processing. On the other hand, and quite surprisingly, participants from Germany and Czechia that were assumed to be the most analytic (longest dwell on objects and shortest saccades), were in fact not significantly different from the participants from Taiwan. Moreover, participants from Ghana and Türkiye that were hypothesized to be somehow moderate in both main metrics were in fact the most analytic with the highest focus on focal objects and the shortest saccades. While not aligning with our initial hypotheses, this finding represents a substantial contribution to the understanding of context sensitivity in scene perception in underrepresented countries, including Ghana, Bulgaria, and Türkiye. Upon examining the relative dwell time allocated to focal objects and the background, a clear conclusion emerges: participants consistently devoted significantly more time to observing the objects compared to countries like Taiwan, Czechia or Germany. Notably, the Taiwan sample exhibited distinct characteristics compared to the other samples, as it displayed comparatively smaller differences in dwell times between objects and background. This finding suggests the presence of holistic patterns in the scanning of complex scenes within the Taiwan sample.

In exploratory analysis of saccadic length changes ($H_{mi}2$) we investigated whether the scanning patterns of participants from individual countries develop during the time from stimulus onset. Follet et al.²² observed

a significant drop in saccadic length after three seconds from the start of the trial. This change in saccadic length suggests a switch from the initial ambient scanning of the scene to the object oriented (focal) processing. Their findings were not replicated in the current study. Moreover, we had initially assumed that the decrease in saccadic length would vary across cultural groups studied, with variations in the timing of the drop following stimulus onset. We expected that in countries with a holistic mindset, the decrease would happen later or be less prominent. However, when examining the average dwell time on focal objects and the average saccadic length as key indicators of holistic and analytic perception in this study (i.e. Ghana representing the most analytic and Taiwan the most holistic), we did not observe any temporal changes in saccadic length that aligned with these expectations. Although it should be noted that such patterns might emerge in some participants if analyzed at the individual level.

Next, we explored the relationship between characteristics of the scenes - number of focal objects (H_{mi3}) and relative size focal objects (H_{mi4}) and the dwell time spent on focal objects. Interestingly, participants from Taiwan and both Turkish samples spent significantly more time on objects in stimuli with one focal object compared to stimuli with two focal objects. It was not surprising that the dwell time on focal objects was rising together with their relative size, as the size of objects on the retina (visual saliency) is one of the factors (apart from other factors such as their centrality or semantic saliency) that draw visual attention⁵⁵.

The final analysis aimed to explore the potential effects of participant age, gender, and socioeconomic status on the dwell time allocated to focal objects (H_{mi5}). However, none of these variables demonstrated a significant impact on the observed dwell time.

While this research has contributed new insights into cross cultural similarities and differences in context sensitivity, it is important to acknowledge its limitations. Although we were able to collect a substantial cross-cultural dataset on scene perception, the final number of participants after data cleaning ($N=408$, divided into seven groups) fell slightly below the target sample size determined through power analysis ($N=456$, calculated for eight groups). Additionally, a sensitivity analysis revealed that we were able to detect small to medium effects in the case of ANOVA, medium to large effects in the case of post hoc tests, and medium effect in TOST. As a result, there is a possibility of an increased risk of Type II errors, which means we may have been less likely to detect small true effects⁵³. Future research with a similar number of countries and with ambition to detect small effects should take this into account and increase sample size.

As mentioned above, the research on holistic and analytic perception commonly compares typical “Western” (North America, Western Europe) and typical “Eastern” (East Asia) countries. Despite our research sample covering a relatively diverse set of countries from Europe, the Near East, Africa, and East Asia, the “Western” end of the spectrum is missing as a potential benchmark for an analytic country. This omission was due to the “higher power” intervention of COVID-19 and the associated restrictions. Moreover, it should be noted that our sample consists solely of university students and the results should not be generalized to the broader populations of the studied countries. It is crucial to recognize that our participants are primarily from larger cities and represent individuals with relatively higher levels of education and wealth within their respective cultures. The future research should therefore focus on deeper exploration of within-country variations of scanning patterns during scene perception, especially in the relatively understudied countries.

Apart from possible data collections in other countries, cultures, or subpopulations, the future research in the field should focus on the following issues. The field of cross-cultural research of perception and cognition suffers from its inability to find individual- and cultural-level predictors of the observed differences. Despite the current attempts to link the differences in perception with psychological constructs such as interdependent and independent social orientation⁵⁶, social class²⁶, or means of sustenance⁵⁷, their results found no strong links or are limited to specific cultural contexts or have not been yet replicated elsewhere.

The progress is, in this respect, also hindered by psychometric and methodological issues connected with self-report scales that are widely used for measurement of the said psychological constructs. Specifically, the research on individualism/collectivism, resp. independence/interdependence encounters issues with adaptability of the self-report scales across cultures, more specifically with measurement invariance across cultures^{58,59}. Therefore, part of the problem is a lack of reliable scales that could be used as predictors for less common cultural samples. For example Vignoles et al.⁶⁰ attempted to validate a self-construal scale across 33 nations. Although this research is generally very impressive, the authors report only “marginally acceptable fit on all indices” which actually translates as a poor fit by the standards in the SEM research field⁶¹.

Besides these broader issues, future research should focus on cross-cultural variations of eye-movement patterns under different experimental tasks and designs. As demonstrated by Yarbus⁶² the nature of the instructions can solely influence the eye-movement patterns of participants. The obtained results were based on participants being instructed to view the pictures and assess their subjective liking. However, it is important to note that different instructions given to participants may lead to varying scanning patterns during scene perception. For example, Senzaki et al.⁶³ observed that cultural differences were strongly mitigated when participants merely observed animated vignettes compared to condition when they were to describe the content of the scene. Similar observation was made by Köster and Kärtner⁶⁴, who argue that context-sensitivity is socialized via a verbal route. Therefore, it would be valuable to replicate this research using alternative instructions or even different task paradigms, such as visual search, change detection, or moving object tracking. A further limitation is that we did not collect post-trial ratings of image familiarity or semantic clarity; cross-cultural differences in how easily a scene is recognised or interpreted could modulate the gaze patterns we report. Future studies should obtain such ratings to disentangle perceptual style from stimulus familiarity.

The timing of stimulus presentation is an additional factor that may have influenced the observed results. It is plausible that the duration of the trials could have impacted eye-movement patterns, such as attention to objects or saccadic lengths, leading to potential differences across the studied samples. For instance, it is possible that the transition from ambient to focal processing, which is associated with shortened saccadic lengths as described by

Follet²², might occur at a later time following stimulus onset or vary in a culturally dependent manner. Moreover, longer presentation times would allow the calculation of eye-tracking metrics that are not illustrative in this research design such as transitions between various ROIs.

It is important to note that not all potentially plausible analyses were conducted or reported in this study. Exploring low-level characteristics of the scenes, such as centrality⁶⁵, visual saliency⁶⁶, or utilizing classification algorithms to assess background complexity, would be valuable additions to further enhance the understanding of the phenomenon. Moreover, relatively new and interesting methods of eye-movement analysis are currently available. Studies based on these methods employ a different approach than the analysis of fixations and saccades present in the current paper. For example Hsiao et al.⁶⁷ developed a statistical method of individual-level comparison of eye-movement patterns based on combination of hidden Markov models and co-clustering that allows for a concurrent clustering of participants in both temporal (position of fixations) and spatial (order of fixations) dimension of eye-movements. Another option might be using at the trial-level the Gini coefficient of dispersion⁶⁸.

Although we harmonised all acquisition parameters and showed that key data-quality metrics (data loss, maximum calibration accuracy threshold) did not differ by site, unmeasured device-specific artefacts can never be ruled out completely³⁴. Importantly, our dependent variables - dwell time and saccade length - are relatively insensitive to the spatial errors below 1°.

Data availability

Preregistration, data, analysis code, and other research materials are available at OSF: (<https://osf.io/73arx/>). Study design, sampling, and analysis plan of this study were pre-registered at OSF before conducting raw data cleaning and analysis. Due to some relevant critique, pre-registration was updated after peer review in previous submission. Deviations from the pre-registration are reported in the Supplement. Analyses reported here should be therefore considered as “exploratory”.

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Author contributions

ČJ: Conceptualization, Methodology, Investigation, Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization; HD: Investigation, Methodology, Writing – Review & Editing; CJ: Formal Analysis, Writing – Review & Editing; LD: Investigation, Formal Analysis, Writing – Review & Editing; KP: Formal analysis, Writing – Review & Editing, Visualization; SZ: Investigation, Writing – Review & Editing; TJ-L: Investigation, Writing – Review & Editing; AA: Investigation, Writing – Review & Editing; DT: Investigation, Writing – Review & Editing; LJ: Investigation, Writing – Review & Editing; DN: Investigation, Writing – Review & Editing; ŠA: Investigation, Writing – Review & Editing; UP: Investigation, Writing – Review & Editing; ŠČ: Conceptualization, Methodology, Investigation, Writing – Review & Editing, Visualization, Supervision, Funding Acquisition.

Declarations

Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix VII

Study VII



OPEN

Exploring cross-cultural variations in visual attention patterns inside and outside national borders using immersive virtual reality

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We examined theories of cross-cultural differences in cognitive style on a sample of 242 participants representing five cultural groups (Czechia, Ghana, eastern and western Turkey, and Taiwan). The experiment involved immersive virtual environments consisting of two salient focal objects and a complex background as stimuli, which were presented using virtual reality headsets with integrated eye-tracking devices. The oculomotor patterns confirmed previous general conclusions that Eastern cultures have a more holistic cognitive style, while Western cultures predominantly have an analytic cognitive style. The differences were particularly noticeable between Taiwan and the other samples. However, we found that the broader cultural background of each group was perhaps just as important as geographical location or national boundaries. For example, observed differences between Eastern (more holistic style) and Western Turkey (more analytic style), suggest the possible influence of varying historical and cultural characteristics on the cognitive processing of complex visual stimuli.

Past research in cross-cultural psychology suggests the existence of systematic differences in perceptual and cognitive domains across nations and cultural groups. This area of research covers a variety of specific cognitive processes, such as object categorization, thinking about contradictions, object-background separation, selective attention to objects and background in complex scenes, processing of global and local features of objects, attention to changes in the visual field, and many others¹.

Following this area of research, a theory of holistic and analytic cognition has been developed². The theory distinguishes two relatively stable modes of cognitive processing, referred to as holistic and analytic cognitive styles, and states that certain individuals should process information from the world prevalently in one of these two distinctive ways. According to this theory, holistic individuals (compared to their analytic counterparts) (a) use more intuitive and less rule-based strategies in object categorization^{3,4}, (b) use dialectical thinking instead of rules of formal logic, (c) are less effective in separating objects from the background⁵ (d) focus more on the background and the relationships between objects and less on the salient (focal) objects and their attributes⁶, (e) focus more on the global features than the local features of objects⁷, and (g) are more sensitive to contextual changes than focal object changes⁸.

Our current research focuses on one of these processes: selective attention to objects and their surroundings (background), sometimes also referred to as context sensitivity. Other authors have previously examined cross-cultural differences in context sensitivity using natural scenes (free-viewing paradigm) in combination with eye-movement recording^{9–11}. Some research has found distinct differences in eye-movement patterns between Chinese and Americans⁹ and Chinese and Africans¹⁰, whereas other studies have supported a null hypothesis on the lack of any systematic cultural differences in people viewing scenes¹¹.

In the present study, we sought to replicate the results of previous experiments on cultural differences in context sensitivity in complex visual environments and to extend this design by transferring the experimental procedure into immersive virtual reality with 3D compositions of virtual environments. This type of adaptation also has two potential benefits over the presentation of 2D scenes: (1) hypotheses on the third dimension

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of the visual world (depth) can be formulated, and (2) given the three-dimensional nature of the visual world, such research can be considered more ecologically valid for everyday visual experience. In this manner, we are responding to the challenge posed by Elvio Blini and his colleagues, who argued that “*depth is a fundamental, yet overlooked, dimension of human perception*” and that “*future studies in vision and perception should be depth aware*”¹².

We created a series of static 3D scenes, each consisting of two focal objects placed in a semantically congruent background environment. Because the focal objects were designed to be visually salient, we hypothesized that they would be of relatively greater interest to analytic individuals. In accordance with i.a. Brouwer¹³, Cryns¹⁴, and Pontius¹⁵, we therefore expected that these participants would spend relatively more time gazing at the focal objects (focal object dwell time) than they would on the background and less salient objects located within the background, whereas holistic individuals would spend relatively less time on the focal objects.

To more closely investigate the possible differences in perception of depth, one of the focal objects was located nearer to the viewer in approximately half of the 3D scenes (for more information, see the “[Methods](#)” section). In these scenes, we hypothesized that the more distant focal object would likely blend more with the background for the analytic participants and that they would therefore dwell less on the distant focal object than the nearer focal object.

A relatively intricate part of the present study was determining a priori which individuals from which specific countries could be expected to exhibit predominantly holistic or analytic patterns in context sensitivity. Most of the research in the field has focused on comparisons between “Western” (USA, Europe) and “Eastern” (Japan, China) samples, with Western samples being relatively consistently more analytic than Eastern samples (for a review, see¹). However, while this conceptualization might be understandable when comparing two culturally distant samples, it doesn’t have to be necessarily understood as dichotomous when comparing multiple less distinct cultures.

Quite the contrary, the East–West dichotomy seems to be rather reductionist and potentially distorting. Moreover, it ignores other potentially influential factors such as characteristics of the environment, socioeconomic status, religion, or other individual-level factors. This is especially valid for large and culturally heterogeneous countries or countries that are not confined to North America or Asia. For example, Chatterjee¹⁶, demonstrates this in reference to India which is commonly perceived as “Eastern” and collectivistic. She argues that India is a very diverse country where some areas tend toward collectivism and others toward individualism. In order to reflect this approach we included two purposefully selected samples from Turkey, the geographically largest and the most populous of the countries included in this research (for details, see the “[Research sample](#)” section).

Furthermore, in line with suggestions made by Matsumoto and Yoo¹⁷, we explored the possible influence of individual-level variables such as the size of the municipality the participant lives in (measured by population), gender, age, experience with living in other countries, number of siblings, socioeconomic status, and study area to “unpack” their possible influence on dependent variables.

In summary, even though we reflect the limits of the original theoretical foundations within the analytic-holistic paradigm, we still find the above-mentioned cross-cultural theories of cognitive style as viable and able to detect differences in cognitive processes even at a more detailed level and with a wider spectrum of cultures.

Our research sample was composed of five cultural sub-samples from Czechia, Taiwan, Ghana, eastern Turkey, and western Turkey (Fig. 1). Based on previous research, we expected the Czech participants to be, on average, the

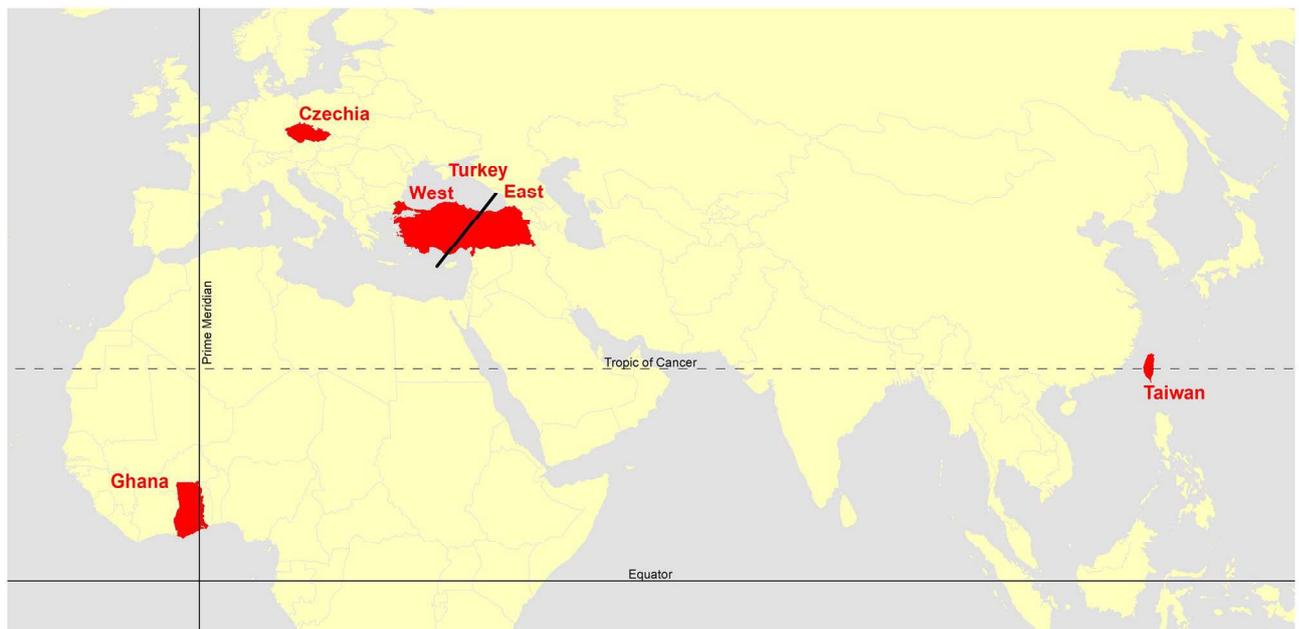


Figure 1. Map indicating the areas of origin of the participants. Created in ArcGIS Desktop 10.8, URL: <https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview>.

most analytic of all the samples^{6,18}, whereas the Taiwanese, as East Asians, were the most holistic^{9,10}. The other three cultural samples should have fallen somewhere between these two samples in terms of context sensitivity. However, in the absence of any eye-tracking research that has applied complex scenes with a free-viewing paradigm to directly compare samples from the Middle East and Sub-Saharan Africa, we were unable to form any strong hypotheses about the holistic/analytic patterns of perception in these three samples.

When we included Turkey in the research, we were careful not to neglect the cultural variance within the country's borders; much data on the socioeconomic development index (data from the Ministry of Development in¹⁹), fertility rate²⁰ and ethnic distribution²¹ according to province indicate significant cultural differences between eastern and western Turkey. Since research examining other research samples and methods^{22,23} has also suggested that participants from eastern Turkey are more holistic than their fellow citizens originating from western Turkey, we considered these two groups as two separate samples that exhibit the above-mentioned expected differences.

Methods

Experimental procedure

Research ethics

The Research Ethics Committee of Masaryk University reviewed the application to conduct the research project and has approved this project (Proposal No.: 0257/2018) to be conducted on 13 March 2019. The nature of methods used, and their administration were performed in accordance with the relevant guidelines and regulations of Masaryk University and national laws. The necessary approvals and permissions to conduct this research were obtained from participating Universities in Ghana (University of Ghana), Turkey (Adnan Menderes University), and Taiwan (National Chengchi University). All local guidelines were followed during the data collection. Informed consent was obtained in writing from all participants.

Virtual reality and eye-tracking hardware and software: HTC Vive Pro head-mounted displays were used with Pupil Labs binocular add-ons to collect eye-tracking data with an estimated accuracy of 0.84° and precision of 0.16°²⁴. The sampling frequency of the eye-tracker was set to 90 Hz to correspond to the default refresh rate of the head-mounted display. The experiment (stimuli sequence, presentation timing) was controlled with a set of utility scripts in the Toggle Toolkit²⁵.

Procedure

Data gathering was conducted by a trained administrator under the supervision of one of the members of the research team. The experiment was conducted in several steps (Fig. 2), as follows: (1) participants read information about the research and signed the informed consent form; (2) using the Hypothesis software²⁶, participants were asked to fill in a sociodemographic questionnaire (size of the municipality participant lives in, gender, age, experience with living in other countries, number of siblings, socioeconomic status, study area, and history of ADHD; for details see Supplement 1); (3) participants underwent a 6-min-long virtual environment adaptation session in a form of stereoscopic video clip to become accustomed to the potentially new experience in virtual reality and to learn the basics of controlling the virtual environment (e.g., moving their heads, an action some participants commonly avoid doing during the first few minutes in the virtual environment; for more information about this topic, see²⁷); (4) the experiment's session in virtual reality. Both the adaptation and experimental sessions were conducted with participants seated, and with no extra movement, constraints were imposed on them.

Each session of the experiment started with the calibration of the eye-tracker using the Pupil Labs native calibration application (6-point calibration with three levels of depth). Although the native calibration application provides feedback to the experiment's administrator about successful calibration, we added a validation procedure to let us check the accuracy of eye movement during validation. The administrator instructed participants to fixate objects on the validation screen and in the case of insufficient accuracy the eye-tracker was recalibrated. If a particular participant repeatedly failed to pass the validation process, data collection for that participant was

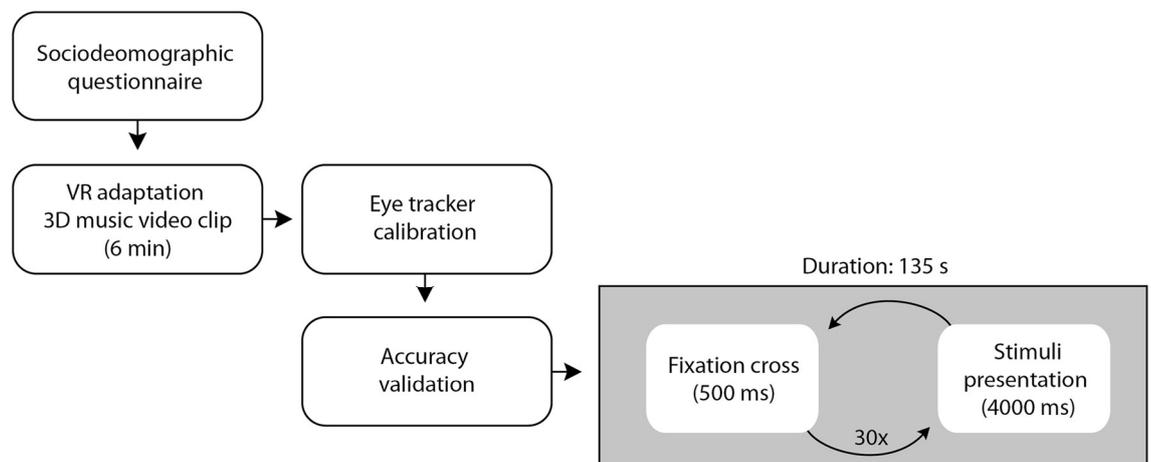


Figure 2. Experimental procedure.

discontinued. Furthermore, during the data cleaning stage, we incorporated the validation data to ensure the integrity of our dataset (for more details, see the “[Data analysis and cleaning procedure](#)” section). After successful calibration and validation, the participants were presented with 30 trials of static virtual environments. The participants were instructed to “*view the scenes freely*” and informed that “*they will be asked for an evaluation of some of the scenes afterward*”. Before the presentation of each scene (4 s per trial), a fixation cross was displayed for 500 ms. After the presentation of all trials, respondents were asked to a) describe in their own words, and b) evaluate how much they liked (very pretty–very ugly) in a subset of the presented scenes. The responses are not used in this study.

Materials

To ensure cross-cultural equivalence and to avoid biases on item level caused by inappropriate adaptation²⁸, all verbal parts of the experiment (i.e. the questionnaire, the instructions) were back-translated by two independent native speakers²⁹ from various cultural backgrounds³⁰. The instructions were as simple as possible to prevent or at least minimize any possible administration biases.

The stimulus material consisted of 30 three-dimensional virtual environments (two for training and 28 for testing). Trials were presented in pseudo-random order (a priori randomized and presented in the same order to all participants and groups). The virtual environments were created in Unity Engine using freely available 3D assets³¹. Each virtual environment consisted of two visually and semantically salient focal objects (e.g., cars and car wrecks, barrels, vases, motorcycles) placed in a complex background (typical background components included sky, horizon, vegetation, rocks, and other less salient man-made objects). Both the general virtual environment (background) and the objects were validated in cooperation with the local experts with the aim to minimize possible cultural influences such as familiarity with the scenes and the objects—all parts of the scene had to be commonly present in all cultures included in this research. Such a step of involving scholars from local cultures should increase the construct equivalence^{32–34}.

In accordance with Brouwer’s note¹³ that too much detail in stimuli may distract the observers’ attention, we deliberately opted for simpler graphics than the utilized immersive virtual reality technology allows for (e.g., photorealistic digital twins of buildings³⁵). Virtual environments also lacked locally specific distinct landscape features and culturally specific objects that could be completely unfamiliar to some cultural groups. On the contrary, the design aimed at commonly used objects.

We used two general virtual environment types in the experiment: (1) scenes in which both focal objects were placed at the same distance from the viewer (Fig. 3 upper part; 16 trials); (2) scenes in which one of the focal objects was placed farther from the viewer (Fig. 3 lower part; 12 trials). Each stimulus was presented for four seconds.

Eye-tracking data processing

Using Unity, we defined object colliders for each focal object since the experiment involved analysis of dwell times on various objects (focal objects and background). These colliders are the 3D equivalents of regions of interest in 2D eye-tracking studies. To correctly classify gaze points, colliders were defined as convex meshes to 110% of the size of the objects (i.e., the colliders did not directly occupy the object’s contours but filled the



Figure 3. Stimuli—two examples of the presented complex environments. In the upper image the truck wreck and a group of barrels (top) represent focal objects at the same distance from the viewer, whereas in the bottom image, the scooter is nearer to the viewer than the red car.

small space around the objects, Fig. 4). Gaze points on all other objects were coded as background gazes. Other research teams (e.g.,³⁶) have previously adopted a similar procedure for studying object hits in virtual reality eye-tracking and provided reliable data while also eliminating the potential inaccuracy encountered with virtual reality eye-trackers.

In the next step, we executed a data cleaning script that filtered corrupt or inaccurate data. Since 50 ms is commonly recognized as a threshold for any cognitive recognition³⁷, we considered gazing at an object for more than 50 ms a visit and rejected gazes below this limit. If a visit was followed by a very short hit (less than 32 ms) on another object followed by a return to the original object, the duration of the gaze on this object could not and after the interruption was merged into one visit to prevent data distortion caused by measurement inaccuracy. Dwell times were calculated for each object category (focal object 1, focal object 2, background) as the sum of the duration of all visits. Data loss (blinks, closed eyelids, eye-tracking desynchronization, etc.) was computed per stimulus in addition to focal object and background dwell time.

Data analysis and cleaning procedure

Before data collection, we conducted a power analysis for one-way ANOVA in *G*Power* (v3.1.9.7³⁸) with the following settings: $f=0.25$, $\alpha=0.05$, $1-\beta=0.80$, number of groups = 5. The effect size was determined according to previous research by Duan¹⁰, who reported large effect sizes for eye-movement data (η_p^2 ranging between 0.12 and 0.77). We decided on a relatively more conservative strategy at the medium effect size threshold. The results specified a minimum sample size of 200 participants (40 per group) to achieve 80% statistical power.

As mentioned above, we gathered virtual reality data from five cultural samples: Czechia, Ghana, Taiwan, eastern Turkey, and western Turkey. All participants were students enrolled at local universities. The participation was advertised in university courses and via student unions. The only exclusion criterion was the presence of severe uncorrected eye defects. Considering the potential experimental mortality typical of this kind of research (e.g., poor data quality and data loss, not all participants completing the experiment), we obtained 297 participants in total. The data were collected as part of a larger test battery that investigated cross-cultural differences in visual perception and included other tasks such as Navon Figures based methods⁷, and complex 2D scenes⁶. Results of those methods have not been published yet. For various reasons, some participants from each country could not be measured or included in the analysis, mainly because of impracticable pupil detection or nausea during the experiment. In this stage, 10 participants were excluded because of technical issues in the data collection process.

To ensure good data quality, we performed a data cleaning procedure. In the first step, we calculated the average data loss from the data loss per stimulus (% of missing eye-tracking records). The threshold for removing a participant was set arbitrarily at 5% of missing records. Twelve participants were removed because of high data loss. The average data loss in the remainder of the sample was 0.6%. The second step involved a qualitative assessment of the validation procedure by two independent evaluators (researchers with high expertise in eye-tracking technology) who rated the quality of each individual validation. The records from the validation scene of each participant were exported by a technical worker and subjected to visual inspection with an emphasis on the accuracy of gaze points on target objects and the absence of undesirable artifacts. Only in the case of agreement on the sufficient quality of the recording were the participants' data accepted for analysis. An additional 21 cases were removed based on poor validation. In the final step, we removed 12 participants based on their reported history of ADHD. The entire cleaning procedure resulted in a dataset of 242 participants (for more details see the next section).

To test the first hypothesis, we performed a one-way ANOVA. First, we summed the duration of visits on both focal objects to obtain a single aggregate focal object dwell time per stimulus; we then calculated the mean focal object dwell time across all 28 test trials. Then, we verified the ANOVA assumptions. Because Levene's test indicated unequal variances across groups ($F=5.44$, $p<0.001$) and the Shapiro-Wilk test suggested normally distributed residuals ($W=0.99$, $p=0.65$), the Welch's degrees of freedom correction for one-way ANOVA was conducted. We also applied Games-Howell post-hoc tests with Tukey HSD correction.

To test the second hypothesis, we performed a mixed ANOVA. Only the twelve stimuli with focal objects at varying distances from the viewer were subjected to this analysis. We calculated the mean dwell time for both types of focal objects. Regarding ANOVA assumptions, the data indicated unequal variance across groups ($F=6.82$, $p<0.001$), sufficient sphericity ($p>0.999$), and non-normal distribution of residuals ($W=0.99$,

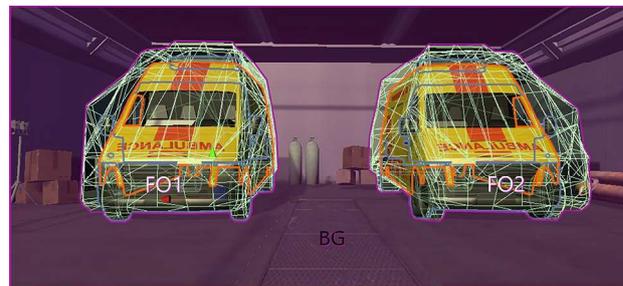


Figure 4. Object colliders. Each focal object (ambulances) possessed an invisible mesh as a collider, set to 110% of the object's size. These colliders served as regions of interest for the eye tracker. All other objects were marked as background.

$p < 0.001$). Three cases (one from Ghana, one from eastern Turkey, and one from western Turkey) were identified as outliers based on a visual inspection of the quantile–quantile plots and consequently removed from the analysis. A repeated check of the ANOVA assumptions suggested unequal variance across groups ($F = 6.86$, $p < 0.001$), spherical data ($p > 0.999$), and normal distribution of residuals ($W = 9.99$, $p = 0.111$). Since Welch's correction is not implemented for mixed ANOVA and at the same time ANOVA is relatively robust for violation of equality of variances, we conducted mixed ANOVA with focal object dwell time as a dependent variable, cultural group as a between-subject factor and type of object (type: closer, further) as a within-subject factor. To overcome issues with inequality of variance, omega squared effect size is reported. All p -values were adjusted using the Holm–Bonferroni method.

We analyzed the data in R using the following packages: *afex*, *effsize*³⁹, *ggforce*, *ggdist*⁴⁰, *ggshades*, *lme4*, *lsr*, *performance*⁴¹, *psych*⁴², *rstatix*, *rmisc*, and *tidyverse*. The data matrices and R code containing the data cleaning procedure are available online at the URL <https://osf.io/2kqts/>.

Research sample

The entire data cleaning procedure resulted in a dataset composed of 242 participants representing five cultural samples: Czechia (42), Ghana (39), Taiwan (51), Turkey East (56), and Turkey West (54). See Table 1 for per-country descriptives of gender and age. For detailed sample descriptives (e.g., socio-economic status, number of siblings, size of municipality of birth, study area), see Supplement 1.

Results

Overall average dwell on focal objects

In the eye-movement analysis, we focused on visits and the respective dwell time on focal objects. Figure 5 shows per-country distributions of the mean focal object dwell time. The means and confidence intervals for each country are summarized in Table 2.

Next, we tested for differences between cultural groups. ANOVA revealed a statistically significant effect of the cultural group on the mean of focal object dwell time with a large effect size, $F(4, 108.84) = 73.93$, $p < 0.001$, $\omega^2 = 0.386$. Post hoc tests (Table 3) indicated that the Taiwanese spent significantly less time observing focal objects than participants from all the other countries. Participants from western Turkey spent significantly more time observing focal objects than all the reported groups apart from Czechia. No significant difference was observed between participants from eastern Turkey and Czechia or Ghana. Participants from Czechia spent significantly more time observing focal objects than participants from Ghana. All significant pairwise differences showed large effect sizes and insignificant comparisons indicated weak to medium effect sizes. Thus, this hypothesis was partially supported. See the Supplement for comparison of dwell time on focal objects and background.

Country	% of females	Age: mean (SD)	Age: range
Czechia (N = 42)	66.7	22.3 (2.08)	18–26
Ghana (N = 39)	46.2	21.3 (0.95)	20–24
Taiwan (N = 51)	68.6	21.8 (2.09)	20–29
Turkey East (N = 56)	33.9	22.4 (1.92)	19–30
Turkey West (N = 54)	25.9	22.0 (1.88)	19–27

Table 1. Sample descriptives ($N = 242$).

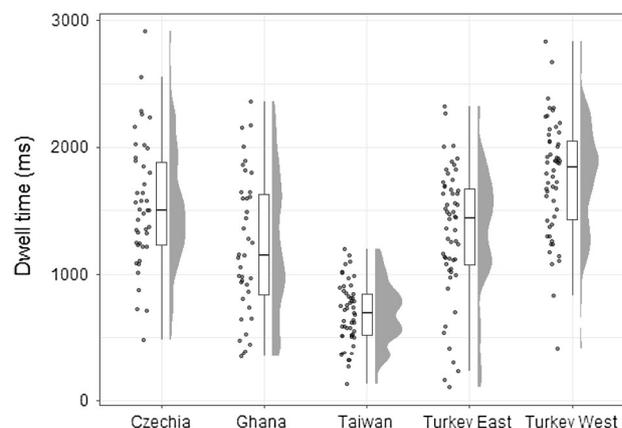


Figure 5. Focal object dwell time per country.

Country	Mean (SD)	lower 95% CI	upper 95% CI
Czechia	1547.14 (506.07)	1389.44	1704.85
Ghana	1217.24 (554.06)	1037.635	1396.85
Taiwan	687.81 (244.53)	619.04	756.59
Turkey East	1326.89 (511.99)	1189.78	1464.00
Turkey West	1760.77 (458.79)	1635.54	1885.99
Total sample	1309.58 (590.94)	1234.75	1384.41

Table 2. Focal object dwell time descriptives per country (in milliseconds; N = 242).

Comparison	Mean difference [95% CI]	p-value	Hedges g [95% CI]
Czechia—Ghana	330 [47, 613]	0.050	0.62 [0.17, 1.06]
Czechia—Taiwan	859 [594, 1124]	<0.001	2.21 [1.69, 2.73]
Czechia—Turkey East	220 [−39, 480]	0.220	0.43 [0.03, 0.83]
Czechia—Turkey West	−214 [−475, 48]	0.215	−0.44 [−0.85, −0.04]
Ghana—Taiwan	529 [259, 800]	<0.001	1.29 [0.83, 1.74]
Ghana—Turkey East	−110 [−375, 156]	0.864	−0.21 [−0.61, 0.20]
Ghana—Turkey West	−544 [−811, −277]	<0.001	−1.08 [−1.51, −0.64]
Taiwan—Turkey East	−639 [−885, −393]	<0.001	−1.56 [−1.99, −1.12]
Taiwan—Turkey West	−1072 [−1322, −825]	<0.001	−2.87 [−3.42, −2.32]
Turkey East—Turkey West	−434 [−676, −191]	<0.001	−0.89 [−1.27, −0.49]

Table 3. Dwell time post-hoc tests: p-values and Hedges g [95% CI].

Dwell time on closer and further objects

In the next step, we examined the potential role of depth in relative focus on focal objects placed closer or further away from the viewer. See Fig. 6 and Table 4 for details.

We performed a mixed ANOVA. The main effect of the country was statistically significant, with a large effect size $F(4, 234) = 34.72$, $p < 0.001$, $\omega^2 = 0.103$, therefore supporting the results of the previous one-way ANOVA. The main effect of the type of object (i.e., object distance from the viewer) was also statistically significant, with a medium effect size $F(1, 234) = 8.84$, $p < 0.001$, $\omega^2 = 0.008$, suggesting that if we investigate all the participants regardless of their country, on average they spend more time on objects which are closer than further. Finally, the interaction between cultural group and object type was also significant, with medium effect size $F(4, 234) = 4.71$, $p < 0.001$, $\omega^2 = 0.009$.

Since the interaction was significant, a more detailed analysis of the results was conducted via simple main effects. The simple main effect of cultural group was significant for both closer, $F(4, 234) = 28.00$, $p < 0.001$, $\eta_g^2 = 0.324$, and further objects $F(4, 234) = 26.30$, $p < 0.001$, $\eta_g^2 = 0.310$. For these differences, however, we did not state any hypotheses, and therefore we did not perform additional post-hoc tests. The simple main effect of the focal object position was significant for Turkey East and Turkey West participants, with medium to large effect sizes. In both of these cultural groups, the participants gazed at the closer focal objects for a longer time. No significant difference was evident in the other three cultural groups, with negligible effect sizes (see Table 5 for details). Since the type of focal object was a binary variable, no post-hoc tests were performed. Overall, the hypothesis concerning systematic cross-cultural differences in depth perception was not fully supported since they were observed only among participants from both Turkish groups.

Dwell on objects and other individual-level variables

In the last step, we performed an exploratory analysis of possible influence of other variables on the dwell time on focal objects. We performed ANCOVA with dwell time on focal objects as the dependent variable, culture as the independent variable, and size of the municipality the participant lives in, gender, age, experience with living in another country, number of siblings, socioeconomic status, and study area as covariates. Apart from a small to moderate effect of gender ($p = 0.010$, $\eta_p^2 = 0.051$), no other variable was in a significant relationship with the dependent variable. The main effect of gender is associated with a decrease in the average dwell for females compared to males. The model with covariates showed the same pattern of differences in focal object dwell time across countries as the basic model (for full results, comparison of models and descriptives by country and gender, see Supplement 1).

Discussion

The paper presents the results we obtained from a study of the cognitive processing of complex visual stimuli in a sample of five cultural groups native to Czechia, Ghana, Taiwan, eastern Turkey, and western Turkey. We used immersive virtual environments as stimuli and an eye-tracking device to measure the participants' oculomotor

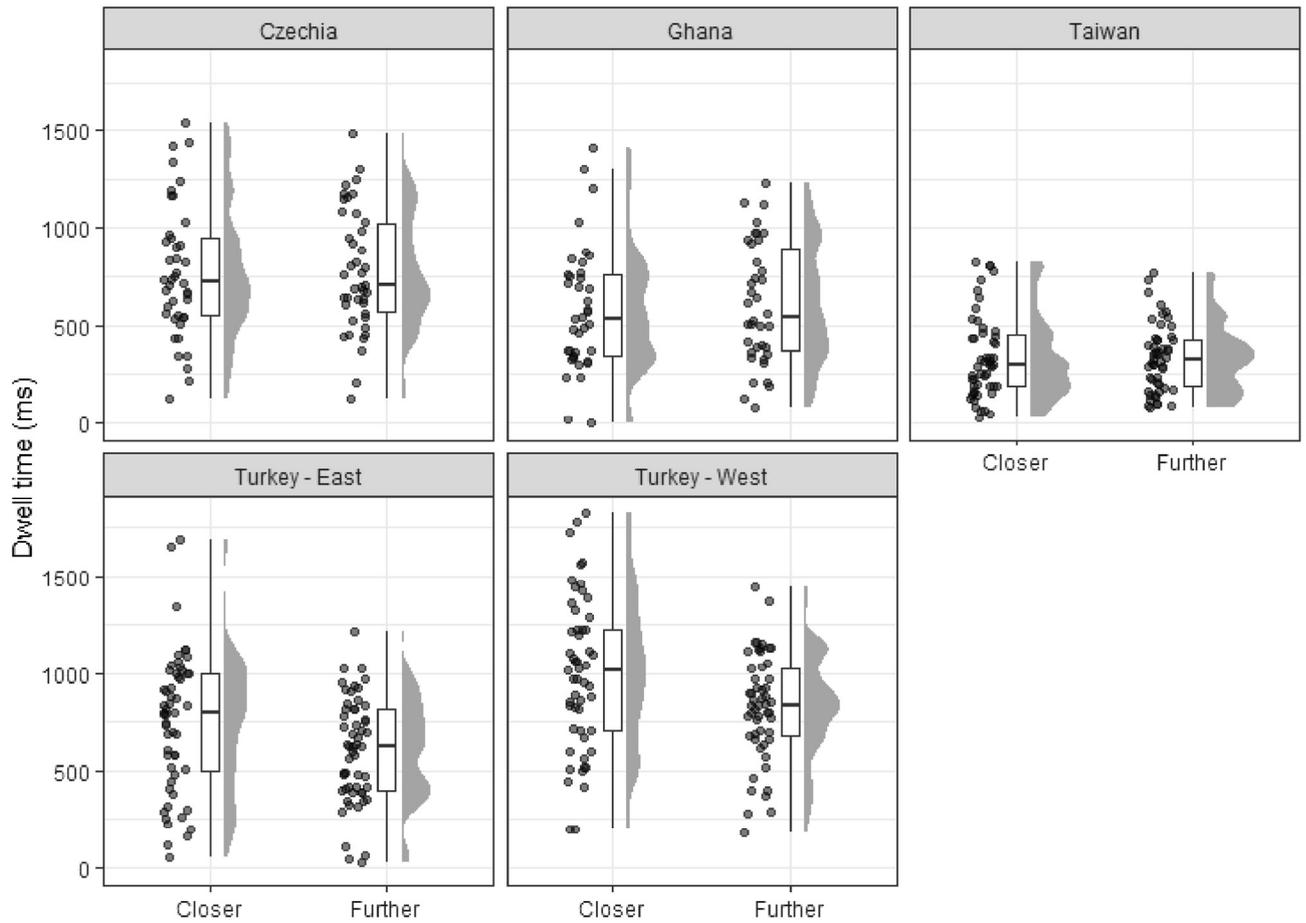


Figure 6. Dwell time on focal objects closer and further from the viewer.

Country	Type of FO	Mean (SD)	lower 95% CI	upper 95% CI
Czechia N = 42	Closer	770.43 (339.08)	664.76	876.09
	Further	775.99 (310.30)	679.29	872.68
Ghana N = 38	Closer	581.55 (320.59)	476.18	686.93
	Further	608.56 (310.45)	506.51	710.60
Taiwan N = 51	Closer	336.87 (215.44)	276.27	397.46
	Further	331.73 (172.45)	283.22	380.23
Turkey East N = 55	Closer	746.11 (357.93)	649.34	842.87
	Further	601.53 (268.25)	529.01	674.05
Turkey West N = 53	Closer	998.57 (391.08)	890.77	1106.36
	Further	824.87 (271.19)	750.11	899.62
Total sample	Closer	692.88 (399.61)	641.96	743.80
	Further	625.26 (318.96)	584.62	665.90

Table 4. Type of focal object dwell time descriptives per country (in milliseconds; N = 239).

Country	Mean difference closer-further (ms)	F	p-value	η^2_g
Czechia (N = 42)	- 5.56 [- 158.10; 146.95]	0.02	1.00	< 0.001
Ghana (N = 38)	- 27.00 [- 187.33; 133.3]	0.40	1.00	0.002
Taiwan (N = 51)	5.14 [- 133.25; 143.54]	0.02	1.00	< 0.001
Turkey East (N = 55)	144.58 [11.31; 277.84]	11.4	0.005	0.051
Turkey West (N = 53)	173.70 [37.94; 309.46]	11.8	0.005	0.064

Table 5. Per country focal object type dwell time post-hoc tests.

behaviors to assess the distribution of attention during a presentation of several virtual environments. Recent similar studies using 2D stimuli were inconclusive on the cross-cultural variance in focusing on salient objects (analytic cognitive style) or on the scene in its entire complexity (holistic cognitive style)^{6,7}, as originally reported by Masuda and Nisbett⁸.

2D images have been previously questioned as suitable proxies for real objects⁴³), whereas 3D representations in an immersive virtual environment appear to provide a potential alternative for further research. Sharing the optimism of de la Rosa and Breidt⁴⁴ on the potential of using virtual reality to enhance the quality of psychological research, we transferred two-dimensional scenes into a three-dimensional virtual world to provide greater ecological validity^{45,46} and the option to include the aspect of depth make virtual reality a suitable tool for examining the aforementioned theories of cross-cultural differences.

In the first presented analysis, which examined the distribution of attention between visually salient focal objects and complex background, the results partially supported the geographic distribution of the cognitive styles we expected according to the assumptions by Masuda and Nisbett⁸. Taiwanese participants spent significantly less time on focal objects than on the rest of the scene, an observation that supports their position as typical representatives of holistic cognitive style. This difference was convincing, especially compared to participants from Czechia, or western Turkey. Interestingly, however, western Turkey was distinct, proving to be the most analytic sample.

We achieved the aim of capturing the possible cultural differences within the Turkish sample: the observed differences in oculomotor behaviour between both Turkish samples agreed with the previously detected within-country differences in cognitive style^{4,23,47}. These differences might be explained by the above-mentioned present-day socio-demographic differences in Turkey and other historical factors. Asia Minor has been a border between Mediterranean and Eastern influences for centuries, and although the western area was under the continuous influence of the Byzantine Empire until 1453, the eastern area experienced significant influence from Persian, Arab, and Seljuk expansion. Differences can also be observed in the second half of the twentieth century, when a large portion of the workforce heading for West Germany was recruited from West Anatolia, Istanbul, and Ankara⁴⁸. A large portion of these workers and their second-generation offspring remigrated back to their homeland which might have reciprocally influenced their home culture.

Surprisingly, the Czech Republic, which was hypothesized as the most analytical, was not distinct from the other studied samples. The object/background attentional patterns for the Czech sample were very similar to the patterns of the sample from Turkey. Whether forced collectivization or other historical phenomena may have caused this variance in central and western European countries in cognitive processes as suggested by Varnum⁴⁹, the underlying perception and evaluation of complex stimuli remains a question. The present study, however, reports some of the first research in the field, comparing the oculomotor patterns of participants beyond commonly studied samples using diverse samples from central Europe, western and eastern Asia, and Africa, and applying methods in a 3D virtual environment⁵⁰. It supports the original theory stating that cultural background affects visual perception, and that culture may be understood as a condensed experience that determines individuals' perceptual schema^{51,52} that drives the exploration activity in the top-down direction⁵³. In the second analysis concerning the differences in processing scenes with focal objects at varying distances, both Turkish samples spent relatively more time looking at closer focal objects. No statistically significant difference of this kind was observed in samples from Czechia, Ghana, and Taiwan.

In summary, we can draw three main conclusions from the present study and the use of virtual reality combined with eye-tracking. A person's cultural group plays a role in visual attention distribution in virtual environments, resp. in their relative attention to focal objects. Second, the findings of significant differences within both Turkey samples underscore the importance of not thinking about countries as culturally monolithic phenomena but being aware that aggregation of data at the national level may camouflage meaningful differences at the within-culture level (see⁵⁴).

Finally, third, there are notable differences in perception of depth (and respectively relative attention to closer and further objects) across the countries, but they are not systematic and easily interpretable at this point. Whereas in Taiwan, Czechia, and Ghana there were practically no differences in attention to closer and further objects detected (differences between 5 to 25 ms), in the case of both Turkish samples they were distinct (145, resp. 174 ms). We find this difference in the patterns of observation of closer and further objects quite interesting, moreover, both cohorts significantly differ in the overall attention to focal object vs. background.

Our research is not without limitations. Generalization of the results is limited by the novelty of the technology: to eliminate the differences in digital literacy of the participants in the study, we selected a student population in which we expected less pronounced differences in digital skills. This particular generation is less likely to have technology-related biases, however, at the same time is most globalized and probably demonstrates a lower level of the culturally based differences the study was aiming at.

The scenes, used as visual stimuli, contain a variety of smaller and larger objects, making them complex in terms of content. However, it is important to distinguish between the complexity of the scene's content and the photorealistic quality of its rendering. In our study, we focused on the former, emphasizing the diversity and arrangement of visual elements rather than striving for photorealism. Manipulation with the level of photorealism of 3D environments⁵⁵⁻⁵⁷ and observation of the effects of this manipulation on the participants' perception and its cross-cultural specifics could offer intriguing prospects for further research.

Apart from this, further cross-cultural eye-tracking research should focus on more controlled manipulations with the objects within the virtual visual field related to monocular and binocular depth cues⁵⁸. For example, on perception and interpretation of conflicting cues, changes in spatial position, and perception of moving objects.

Finally, an important limitation of this study concerns the operationalization of culture within our cross-cultural research framework. We acknowledge that the issue of equating location with culture is a persistent challenge in quasi-experimental laboratory studies of this nature. While exploring more refined cultural subgroups

or local cultures within each studied region might offer valuable insights, it would necessitate larger samples and the inclusion of established culture measurement scales, such as individualism/collectivism or independent/interdependent self-construal, as explanatory variables. However, our previous attempts at validating these methods encountered difficulties^{28, 59}, and we found it necessary to prioritize further developments in culture operationalization methods for more accurate cross-cultural comparisons.

Data availability

The dataset, data-analytic scripts (in R), and supplementary material are accessible in the Open Science Foundation (OSF) repository at the following URL: <https://osf.io/2kqts/>. This study was not preregistered.

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Author contributions

Š.A.: conceptualization, methodology, investigation, writing—original draft, writing—review and editing, visualization; Č.J.: formal analysis, data curation, writing—original draft, writing—review and editing, visualization; U.P.: methodology, formal analysis, resources, data curation, writing—original draft; T.J.-L., S.Z.: investigation, writing—review and editing; G.L.: investigation, writing—review and editing; L.D.: formal analysis, writing—review and editing; F.J.: methodology, writing—review and editing; Š.Č.: conceptualization, methodology, investigation, writing—review and editing, visualization, supervision, funding acquisition.

Competing interests

The authors declare no competing interests.

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Appendix VIII

Study VIII

Cross-Cultural Differences in Cognitive Style, Individualism/Collectivism and Map Reading between Central European and East Asian University Students

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The article examines cross-cultural differences encountered in the cognitive processing of specific cartographic stimuli. We conducted a comparative experimental study on 98 participants from two different cultures, the first group comprising Czechs ($N = 53$) and the second group comprising Chinese ($N = 22$) and Taiwanese ($N = 23$). The findings suggested that the Central European participants were less collectivistic, used similar cognitive style and categorized multivariate point symbols on a map more analytically than the Asian participants. The findings indicated that culture indeed influenced human perception and cognition of spatial information. The entire research model was also verified at an individual level through structural equation modelling (SEM). Path analysis suggested that individualism and collectivism was a weak predictor of the analytic/holistic cognitive style. Path analysis also showed that cognitive style considerably predicted categorization in map point symbols.

Key words: cognitive style, cross-cultural differences, categorization, individualism/collectivism, analytic/holistic

Introduction

The objectives of the study were 1) to explore the cross-cultural differences between Central European and East Asian populations at three distinct levels and 2) to examine how these levels were connected. The presented research examined whether the selected populations differed in the degree of individualism/collectivism and the cognitive style measured by the Compound Figure Test

(CFT), and whether cultural differences manifested during cartographic task solving, specifically in the categorization of multivariate point symbols.

The theory of analytic and holistic (A/H) cognition postulates the existence of distinct cognitive and perceptual styles – relatively stable ways of cognitive processing (for review, see Masuda, 2017; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005; Nisbett, Peng, Choi, & Norenzayan, 2001). The majority of research in this field focuses on comparing the charac-

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teristics of cognitive processes in two world regions: the "West" (e.g., North America, Western Europe) and the "East" (mainly the countries of East and Southeast Asia such as China, Japan, South Korea, etc.; Nisbett, 2003). The theory of A/H cognitive style assumes that Westerners adopt relatively more analytic cognitive style and East Asians the holistic one. A/H cognitive style is defined as "*the tendency for individuals to process information either as an integrated whole or in discrete parts of that whole*" (Graff, 2003, p. 21). Although the primary focus of the theory is the comparison of cognitive processes among cultures, it does not rule out the existence of within-culture individual differences in these processes. In other words, if we compare two people from a certain cultural background, one can perceive relatively more analytically, while the other perceives more holistically.

The A/H model is based on the classic Witkin's model of field dependent/independent cognition (Witkin, Moore, Goodenough, & Cox, 1977) and the Gestalt principles of perceptual grouping and figure-ground organization (Wagemans et al., 2012). Recent findings suggest that many differences exist among people in higher cognitive processes, such as categorization, classification, decision-making, reasoning and causal attribution, and the lower perceptual processes related to attention, such as detection of change and field dependence (for review, see Nisbett et al., 2001; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). More precisely, people perceiving relatively more analytically tend to focus more on perceptually salient (focal) objects and less on background and contextual information, and on the relationships between objects in the perceptual field (Chua, Boland, & Nisbett, 2005; Masuda & Nisbett, 2001; Nisbett & Masuda, 2003). Furthermore, people perceiving relatively more analytically are also less dependent on external reference frameworks than their holistic counterparts (Ji, Peng, & Nisbett, 2000; Kitayama, Duffy, Kawamura, & Larsen, 2003), and are less sensitive to contextual changes while being more sensitive to changes in focal objects (Masuda & Nisbett,

2006). Researchers believe that cognitive style also affects the processes of categorization and classification. Whereas analytic individuals categorize objects by applying formal rules of reasoning, holistic individuals categorize objects by their overall (or holistic) qualities, similarity and mutual relationships (Chiu, 1972; Ji, Zhang, & Nisbett, 2004; Norenzayan, Smith, Kim, & Nisbett, 2002).

The value dimension of individualism and collectivism (I/C) in cross-cultural research is commonly related to A/H cognitive style and often used as a predictor of cognitive style and other psychological phenomena (for review, see Oyserman, Coon, & Kemmelmeier, 2002). Some research suggested that collectivistic individuals are field dependent and holistic, whereas people from predominantly individualistic societies are field independent and analytic (Ji et al., 2000; Nisbett, 2003; Nisbett et al., 2001; Triandis & Gelfand, 1998). However, the relationship between I/C and A/H cognitive styles is rarely measured at the individual level, and many authors have only assumed the aforementioned relationships. Other research has failed to find any empirical evidence at all of relationships at the individual level between I/C and A/H cognitive styles (e.g., Davidoff, Fonteneau, & Fagot, 2008; McKone et al., 2010).

In the current literature though, theoretical considerations (e.g., Hermans & Kempen, 1998; Matsumoto, 1999) and empirical evidence (e.g., Levine et al., 2003; Oyserman et al., 2002; Takano & Osaka, 1999; Takano & Osaka, 2018) can be found, criticizing this dichotomous approach as overly simplifying and reductionist. Post-communist European countries are significantly more holistic and collectivistic than Western Europe (Varnum, Grossmann, Katunar, Nisbett, & Kitayama, 2008). Other findings suggest the existence of significant cultural differences not only across national borders (e.g., Federici, Stella, Dennis, & Hündsfelt, 2011; Kitayama, Park, Sevincer, Karasawa, & Uskul, 2009; Varnum et al., 2008) but also between people from different regions in a single country (e.g., Kitayama, Ishii, Imada, Takemura, & Ramaswamy, 2006; Knight &

Nisbett, 2007; Uskul, Kitayama, & Nisbett, 2008).

These critical findings suggest that the dichotomous model of cognitive styles might be overly reductionist. An alternative model was proposed by Kozhevnikov, Evans, and Kosslyn (2014). Their model is based on an older model by Nosal (1990). It emphasizes the ecological nature of cognitive style that is viewed as a pattern of cognitive adaptation to the environment. Cognitive style is in this model environmentally dependent, flexible and task specific. This model is hierarchical in the form of a cognitive-style matrix organizing cognitive styles on two axes: a) levels of information processing (perception, concept formation, higher-order processing, metacognitive processing), and b) cognitive style families (context dependence and independence, rule-based and intuitive processing, internal and external locus, integration and compartmentalization). According to this model, various components of cognitive style would not have to be inevitably (cor)related – a specific environment could, for example, elicit development of local processing (analytic characteristic) and focus on holistic regions of the map (holistic characteristic). This theoretical model might explain the absence of correlations between various facets of cognitive style reported in some studies (e.g., Hakim, Simons, Zhao, & Wan, 2017; Kster, Castel, Gruber, & Kärtner, 2017).

It should be noted that the number of empirical studies that extend beyond the East-West dichotomy and explore the nature of cognitive style and related factors in other cultural regions, such as Central Europe, is rather limited (with the exception of, for example, Cieřlikowska, 2006; Čeněk, 2015; Kolman, Noorderhaven, Hofstede, & Dienes, 2003; Stachoň et al., 2018; Varnum et al., 2008). The current research suggests that the people of Central Europe are rather moderately analytical in cognitive style and relatively, although not extremely, individualistic.

As mentioned above, the study employed cartographic tasks and stimuli in order to explore the manifestation of cognitive style. This

follows research that has evaluated cartographic visualization methods that began with the publication *The Look of Maps* (Robinson, 1952). These methods gradually developed into the complex field of cognitive cartography. Subsequent to cognitive cartography, map-psychology research was later introduced by Montello (2002). This approach uses maps as stimuli in order to understand human perception and cognition. Examples of map-psychology research include studies on the influence of alignment and rotation on memory (Tversky, 1981) and the influence of cognitive style while working with bivariate risk maps (Šařinka et al., 2018). Categorization in cartographic stimuli was part of the work of Lewandowski et al. (1993), and research conducted around the same time anticipated cross-cultural differences in map reading (e.g., MacEachren, 1995; Wood, 1984) that was ultimately observed (e.g., Angsűsser, 2014; Stachoň et al., 2018; Stachoň et al., 2019). From the cross-cultural perspective, especially in A/H theory, a most interesting study was conducted by McCleary (1975), who examined the categorization of map point symbols. The author found differences in the clustering of dot symbols and identified two user groups from these findings: atomists and generalists, who analogously correspond to the concept of A/H cognitive style. Nevertheless, another study (Sadahiro, 1997) did not confirm this grouping, even though the author also discovered individual differences in the clustering of dot symbols in maps (cf. Sadahiro, 1997).

Consequently, the objective of this research was to further investigate the nature and manifestation of cognitive style in relation to variables such as individualism/collectivism in the culture of Central Europe (Czechia), compared to typical Eastern Asian cultures (China and Taiwan) – specifically, 1) to analyze cross-cultural differences between these two samples in I/C, visual perception (global versus local distribution of attention) and categorization (clustering) in map stimuli, and 2) to verify the entire theoretical model of relationships between I/C and A/H cognitive styles at an individual level and estimate the relationship be-

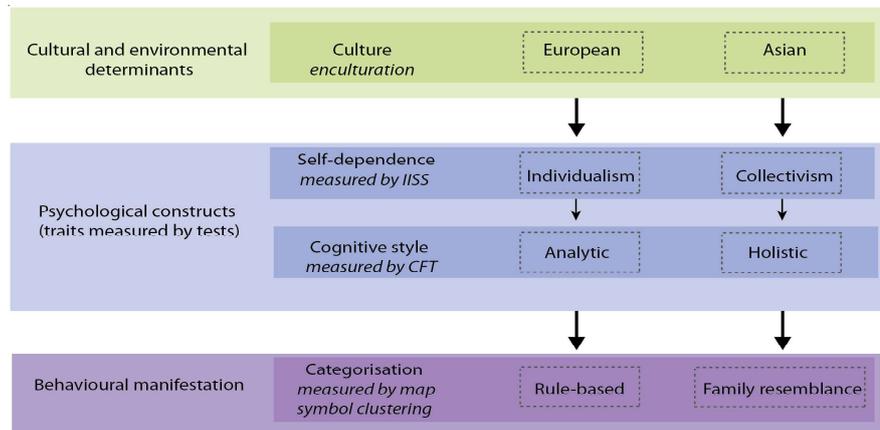


Figure 1 Research model

tween I/C and selected manifestations of A/H cognitive style (global/local attention) and map reading (categorization; see Figure 1).

Methods and Procedures

To achieve the above-mentioned objectives, we applied several methods (described in detail below) using Hypothesis online testing platform (see Procedure section). We also collected sociodemographic information such as age, gender, socioeconomic status (SES), cartography skills, eye defects, number of siblings, etc.

Independent and Interdependent Self Scale

To measure the individual-level I/C, we administered the IISS – *Independent and Interdependent Self Scale* (Lu & Gilmour, 2007). The IISS is derived from the CSC – *Self-Construal Scale* (Singelis, 1994), the *Individualism-Collectivism Scale* (Triandis & Gelfand, 1998) and the concept of independent/interdependent self-construal (Markus & Kitayama, 1991). The IISS comprises 42 (21 for the Independent and 21 for Interdependent Self-Construal Scale) seven-point Likert-type numerical items (1 = strongly disagree, 7 = strongly agree). The

original version of the questionnaire was administered in simplified Chinese (Lu & Gilmour, 2007). It contains items such as “I believe that people should try hard to satisfy their interests.” (independent subscale) or “I believe that family is the source of our self.” (interdependent subscale). The Czech version of the questionnaire was translated from English in parallel by three independent translators. Europeans should have higher independent self-construal (individualistic), and East Asians should be more interdependent (collectivistic; Markus & Kitayama, 1991).

Compound Figure Test

The perceptual factors of cognitive style, more specifically the global and local distribution of attention, were measured using the CFT – *Compound Figure Test*, which is a modified version of the Navon method (Navon, 1977) and has been previously used in several studies (e.g., Kukaňová, 2017; Opach et al., 2018; Šašinka et al., 2018). The CFT comprises six practice trials and 32 test trials (blocked design, same 16 trials for both local and global processing). Number of trials was considered satisfactory based on previous research (Davidoff et al., 2008; von Mühlénen, Bellaera,

Singh, & Srinivasa, 2018). Each trial involves presenting one “Navon figure” – a large number composed of copies of a smaller different number (Figure 2). In the local trial, participants were asked to identify the small numbers as quickly as possible. In the global trial, they were required to identify the large number. Participants used computer mouse to respond. Reaction time and correct identification were measured in each trial. The average reaction time and average success rate was calculated separately for the local (local reaction time, indicating analytic processing) and global (global reaction time, indicating holistic processing) trials.

The main output of the CFT is the global precedence score, which is computed as the difference between the absolute global and local reaction times (e.g., Gerlach & Poirel, 2018; McKone et al., 2010). High values of the global precedence score indicate a holistic cognitive style (global precedence), low or even negative values indicate an analytic cognitive style (local precedence). According to previous research, people should generally perceive global features more quickly than local features (Navon, 1977). Furthermore, analytic perceiv-

ers should be relatively quicker in local and relatively slower in global tasks than holistic perceivers (Peterson & Deary, 2006).

Categorization of Multivariate Map Symbols

Map reading and understanding is considered as a part of visual literacy (Peña, 2017). In addition, the maps represent the complex stimuli, which enable the user not only to understand the presented information but also to derive the additional information (Morita, 2004), therefore we used the cartographic stimuli. The cartographic visualization of multiple phenomena is known as multivariate mapping. Multivariate point symbols are one possible multivariate mapping method (Slocum, McMaster, Kessler, & Howard, 2005). We created specific cartographic tasks for purposes of our experiment. Categorization was measured with *CMMS – Categorization of Multivariate Map Symbols*, which is based on previous research in categorization (Chiu, 1972; Ji et al., 2004; Norenzayan et al., 2002) and on the relationship between cognitive style and map reading (e.g., Herman et al., 2019; Kubiček et al., 2016; Opach, Popelka, Doležalová, & Rod, 2018; Stachoň et al., 2018; Šašinka et al., 2018). The CMMS measures a specific component of categorization, namely clustering (cf. McCleary, 1975; Sadahiro, 1997).

The method comprised three practice trials and twenty test trials. The administration took between 15 and 30 minutes. In each trial, a fictional map comprising multiple territorial units was presented. Each territorial unit contained one map symbol (Figure 3).

The map symbols contained information about the four attributes of a particular spatial unit, namely food costs (originally blue color, top left position), housing costs (originally red color, top right position), transport costs (originally yellow color, bottom left position) and costs of leisure activities (originally green color, bottom right position), which were indicated by the color and size of the map symbol components (Figure 4). The position and color of the abovementioned attributes were kept constant, only their size was manipulated.

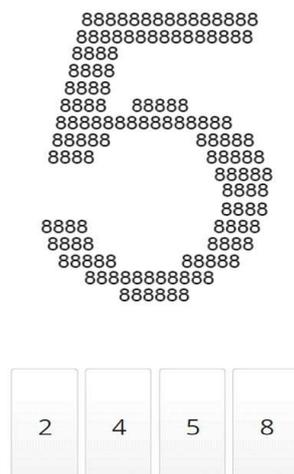


Figure 2 Example of the Navon figure used in the CFT

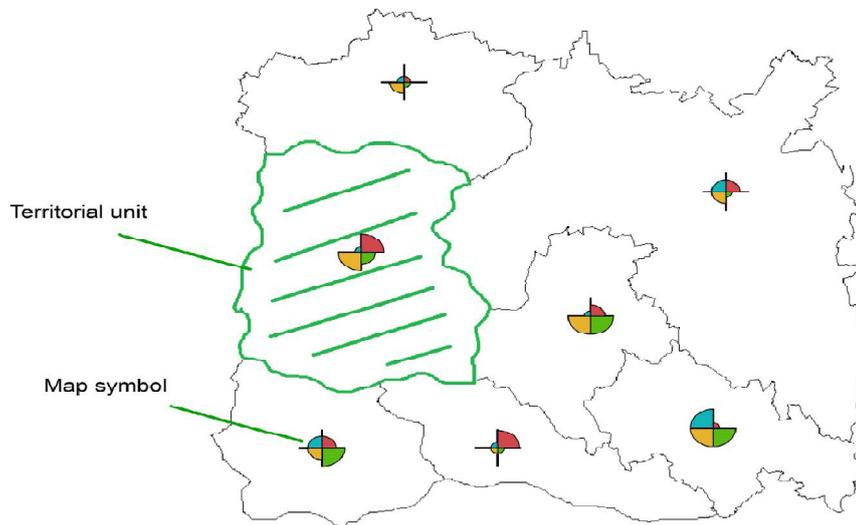


Figure 3 Territorial unit and map symbol in CMMS

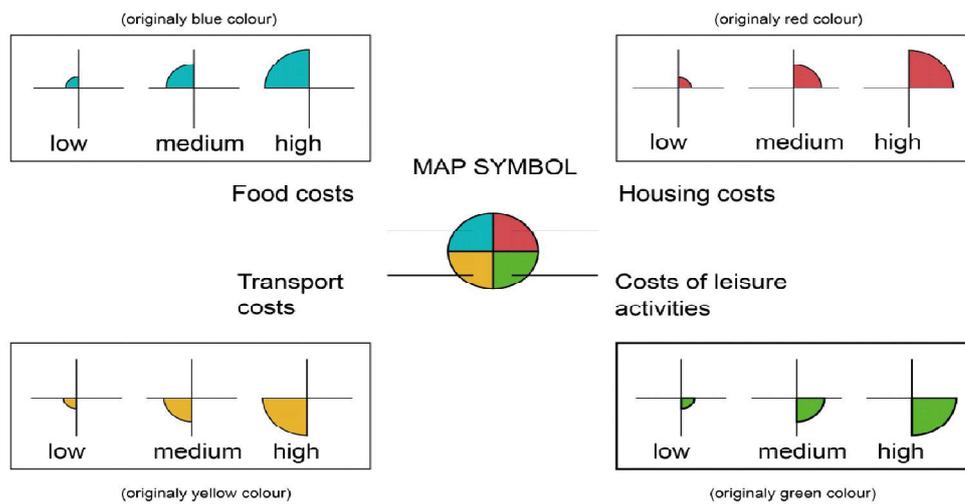


Figure 4 Multivariate map symbol (descriptions were in Czech and traditional/simplified Chinese languages)

Each map was intentionally created to contain one “holistic” and one “analytic” region comprising several territorial units defined by a specific combination of map symbol characteristics (Figure 6). In the analytic region, one of the map symbol components was kept constant and the rest were random (one-dimensional rule); in the holistic region, all map symbols had globally similar components, but none

of them were constant (overall-similarity rule, see Figure 5). The remaining map symbol components were completely random to avoid any categorization rule. The analytic and holistic areas were balanced with respect to reading direction.

In group A) the maximum value of the blue parameter (food costs, upper left) was a common attribute in all symbols. In group B), no

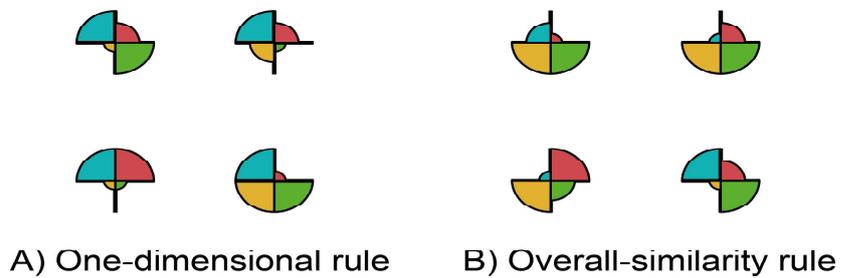


Figure 5 Example of the used analytic A) – left, and holistic B) – right, categorization rules

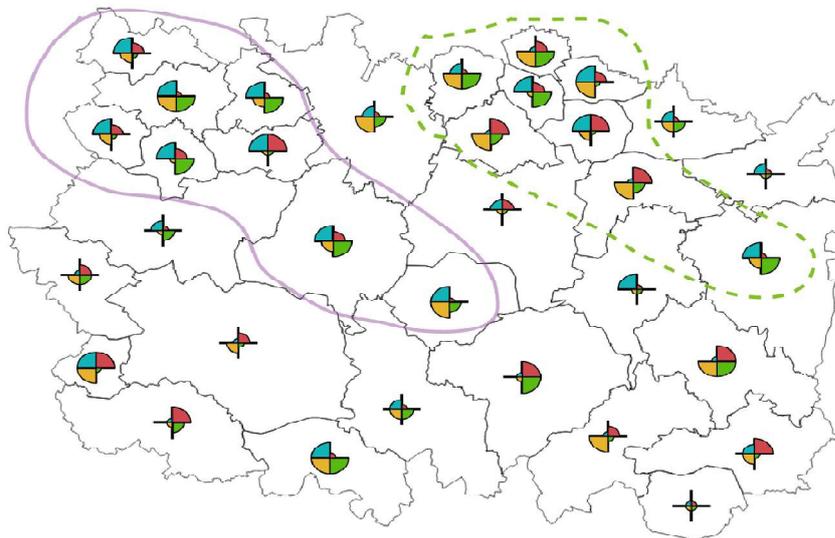


Figure 6 Example of constructed analytic (left solid line) and holistic (right dashed line) map regions

specific attribute was common to any symbol; they shared overall similarity and equal distribution of values in different parameters (2x maximum, 1x medium, and 1x minimum). Alternative map symbols were created according to principles published by Norenzayan et al. (2002).

Participants were asked to identify and mark a continuous map region comprising at least four territorial units that, according to their judgment, belonged together. The CMMS reported each trial result as a value between -1 and 1, where a negative value is defined as a holistic categorization and a positive value is defined as an analytic categorization. This value represented the agreement between the predetermined holistic and analytic regions and the real marked areas. A value of ± 1 represented total agreement, while 0 did not represent any agreement. A control value, calculated as the ratio of marked territorial units within the predetermined areas to the sum of all marked territorial units, was also reported to exclude participants who had incorrectly marked only a negligible number of predetermined areas. A value of .60 and higher was considered a valid response, and therefore 40% or less marked territorial units beyond predetermined areas. For example, if a trial consists of 10 analytic, 10 holistic and 30 random areas and a participant marks out 11 areas (7 analytic and 4 random), his/her control value is valid (analytic marked areas/all marked areas = $7/11 = .636$) and his/her score is .70 (analytic marked areas/all analytic areas = $7/10 = .70$).

From the research mentioned above, we hypothesized that people with a holistic cognitive style will show a tendency to mark out holistic regions and people with an analytic cognitive style will mark out analytic regions. Analogously, we also assumed that East Asians will mark out the holistic area more often (and the analytic area less often) than Czechs.

Research Sample

Before data were collected, a power analysis in *G*Power* (v. 3.1.9.2) was conducted. Setting

power at .80 and effect size f at .280 was sufficient to test at least 104 participants (52 from each culture).¹

We gathered data from 103 participants. Five participants were excluded from further data analysis because of missing data. Out of the remaining 98 participants, 53 participants were Central Europeans (Czech), and 45 participants were East Asians (22 Chinese, 23 Taiwanese). All participants were university students, the majority (57.1%) were women and most of them studied psychology (69.4%). The age range was 16–55 years ($M = 25.4$, $SD = 5.52$). From previous studies it seems that several demographic variables are relevant to cognitive style, therefore, we gathered information about cartographic skills and experience (Ooms et al., 2016), SES (Grossmann & Varnum, 2011), marital status (Bartoš, 2010), size of residence (Jha & Singh, 2011), number of siblings (based on the number of family members in residence, see Grossmann & Varnum, 2011) or field of study (Choi, Koo & Choi, 2007). The detailed descriptive characteristics of the sample are shown in Table 1.

Our research sample was consequently adequate for testing the hypotheses in the first section of results (Cross-Cultural Differences). In the second section (Relationship between Sociocultural, Perception and Cognitive Factors), however, with respect to the sample size, more demanding methods of statistical analysis were used, such as SEM, specifically path analysis. The sample size was relatively inadequate in this case (according to Ding, Velicer, & Harlow, 1995, the minimum sample size for conducting SEM is about 100–150). The results of SEM therefore needed to be interpreted cautiously. Normality tests were performed for all subscales of the methods used. Non-parametric statistics were used, where the data were not normally distributed.

¹ The value of f was selected from previous cross-cultural research using the Navon method, in which the effect sizes were .229–.886 ($M = .410$, $SD = .216$; e.g., Fu, Dienes, Shang, & Fu, 2013; McKone et al., 2010; Tan, 2016). We selected the middle effect size value $f = .280$.

Table 1 Demographic characteristics of the participants

		Western Culture		Eastern Culture	
		Czechia	China	Taiwan	East Asia Total
Gender	Male	25 (47.2%)	7 (31.8%)	10 (43.5%)	17 (37.8%)
	Female	28 (52.8%)	15 (68.2%)	13 (56.5%)	28 (62.2%)
Marital status	Single	31 (58.5%)	16 (72.7%)	13 (56.5%)	29 (64.4%)
	Married	-	2 (9.1%)	2 (8.7%)	4 (8.9%)
	In a relationship	22 (41.5%)	4 (18.2%)	8 (34.8%)	12 (26.7%)
Socioeconomic status	Poor	1 (1.9%)	-	1 (4.3%)	1 (2.2%)
	Low income	6 (11.3%)	4 (18.2%)	1 (4.3%)	5 (11.1%)
	Middle income	24 (45.3%)	6 (27.3%)	13 (56.5%)	19 (42.2%)
	Upper-middle income	19 (35.8%)	7 (31.8%)	6 (26.1%)	13 (28.9%)
	High income	3 (5.7%)	4 (18.2%)	2 (8.7%)	6 (13.3%)
Residence (population)	< 1K	6 (11.3%)	2 (9.1%)	-	2 (4.4%)
	1–10K	11 (20.8%)	1 (4.5%)	4 (17.4%)	5 (11.1%)
	10–50K	8 (15.1%)	1 (4.5%)	6 (26.1%)	7 (15.6%)
	50–100K	14 (26.4%)	2 (9.1%)	1 (4.3%)	3 (6.7%)
	100–500K	12 (22.6%)	4 (18.2%)	5 (21.7%)	9 (20%)
	500K–1.5M	2 (3.8%)	4 (18.2%)	1 (4.3%)	5 (11.1%)
	1.5M–3M	-	3 (13.6%)	4 (17.4%)	7 (15.6%)
	3M >	-	4 (28.2%)	2 (8.7%)	6 (13.3%)
Field of study	Psychology	39 (73.6%)	12 (54.5%)	17 (73.9%)	29 (64.4%)
	Other	14 (26.4%)	10 (45.5%)	6 (16.1%)	16 (33.6%)
Number of siblings	0	6 (11.3%)	3 (13.6%)	-	3 (6.7%)
	1	31 (58.5%)	14 (63.6%)	12 (52.2%)	26 (57.8%)
	2	11 (20.8%)	2 (9.1%)	10 (43.5%)	12 (26.7%)
	3	4 (7.5%)	1 (4.5%)	-	1 (2.2%)
	4 or more	1 (1.9%)	1 (4.5%)	1 (4.3%)	2 (4.4%)
Age range (mean, SD)		20–33 (M 23.6, SD 2.32)	18–46 (M 27.5, SD 7.43)	16–55 (M 27.5, SD 7.24)	16–55 (M 27.5, SD 7.25)

Procedure

Participants were volunteers contacted through university websites and social networks Facebook (Czech and Taiwanese) and WeChat (Chinese). The aforementioned methods were administered in either simplified/traditional Chinese or Czech on PCs using the Hypothesis online testing platform (Popelka, Stachoň,

Šašinka, & Doležalová, 2016; Šašinka, Morong, & Stachoň, 2017) in the presence of an instructor. For their participation the participants got a small reward (USB flash disc) or course credits. The sequence of the tests was 1) CFT, 2) CMMS, 3) IISS, 4) sociodemographic questionnaire. The length of the entire procedure was approx. 35–55 minutes.

Results

The data were processed with *IBM SPSS Statistics* (v. 25), *IBM SPSS Amos* (v. 25) and *R* (v. 3.4.4, *Lavaan* and *SemTools* packages). The results are presented in two sections: *Cross-Cultural Differences* and *Relationship between Sociocultural, Perceptual and Cognitive Factors*. Analysis of the differences between Taiwanese and Chinese participants and also the individual differences between relevant sociocultural variables (e.g., SES, gender, number of siblings, age) were also performed, with no significant differences found in any of the variables. Because of these results, we combined Taiwanese and Chinese participants into a single “Chinese/Taiwanese” group for any subsequent statistical analysis.

Cross-Cultural Differences

The IISS Questionnaire had a satisfactory reliability in both the independent $\alpha = .895$ (Czech version $\alpha = .815$, Chinese version $\alpha = .929$) and interdependent $\alpha = .872$ (Czech version $\alpha = .795$, Chinese version $\alpha = .906$) subscales. Furthermore, the subscales did not correlate

with each other (Spearman partial $r_s = .155$, $p = .177$, culture was a control variable).

The Chinese/Taiwanese were relatively more collectivistic (interdependent subscale) and less individualistic (independent subscale) than the Czechs. The Chinese/Taiwanese scored an average of 5.17 ($SD = .761$) in the collectivistic subscale and 5.18 ($SD = .911$) in the individualistic subscale, whereas the mean scores of the Czechs were 4.66 ($SD = .564$) in the collectivistic subscale and 5.35 ($SD = .502$) in the individualistic subscale (Figure 7). The statistical significance of these differences was tested with one-way ANOVA. The differences were significant only in the case of collectivism: $F(1, 96) = 14.456$, $p < .001$, with medium effect size ($\eta^2 = .131$). No significant differences were found between the groups in the individualism subscale (Mann-Whitney $U = 1105.5$, $p = .535$, $r = .063$). The data were also analyzed with respect to sociodemographic variables. No other significant relationships were observed (for the complete list of collected variables, see Table 1).

A medium correlation was found between both local and global CFT tasks (Spearman partial $r_s = .564$, $p < .001$, culture was a control variable). Two participants were removed from

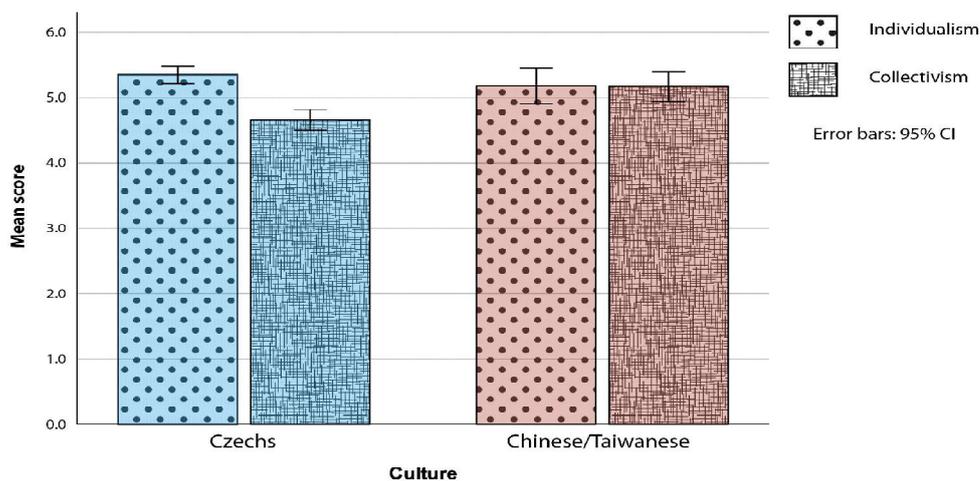


Figure 7 IISS – mean scores

further analysis because of their high error rates (more than four errors in each task).

The results suggest that all participants had significantly quicker reaction times in the global task than in the local task (Wilcoxon signed-rank test $Z = -6.634$, $p < .001$, $r = -.677$). The findings also show that Czechs were quicker than Chinese/Taiwanese in both local and global tasks. The average reaction time of the Czech participants in the global task was 0.99 sec. ($SD = .209$) compared to the Chinese/Taiwanese participants with an average reaction time of 1.66 sec. ($SD = .466$). A similar pattern was observed in the local task, where the average reaction time of the trial solution was 1.13 sec. ($SD = .144$) for the Czechs and 1.77 s ($SD = .387$) for the Chinese/Taiwanese participants (Figure 8). Czechs were significantly quicker in both the global ($U = 204$, $p < .001$, $r = -.711$) and local ($F(1, 95) = 121.960$, $p < .001$, $\eta^2 = .562$) tasks, with large effect sizes.

These differences in reaction times, however, cannot be interpreted in the A/H paradigm as any difference in cognitive style but rather as differences in the emphasis that both groups placed on the speed of the CFT solution (Kukaňová, 2017; Yates et al., 2010). We also calculated the global precedence score

using the aforementioned procedure of difference, specifically by subtracting the local reaction times from global reaction times. Although the Czech participants had a relatively higher global precedence score ($M = .139$, $SD = .210$) than the Chinese/Taiwanese participants ($M = .108$, $SD = .574$), this difference was not significant ($U = 949$, $p = .083$, $r = -.175$) (Figure 9).

The final method applied was CMMS. Four participants were removed from further analysis because of their high error rate (participants that marked less than three territorial units into one continuous map region). The results on a scale between -1 (holistic) to 1 (analytic) show that Czechs categorized in maps more analytically ($M = .044$, $SD = .360$) and East Asians categorized in maps more holistically ($M = -.063$, $SD = .172$) (Figure 10). This cultural difference was statistically significant ($U = 795$, $p = .021$), with a small effect size ($r = -.235$). However, the results show that both groups used a similar cognitive style to categorize map symbols and only small differences in cognitive strategies were found. Moreover, both groups scored relatively close to zero, which is probably caused by using various categorization strategies across different trials,

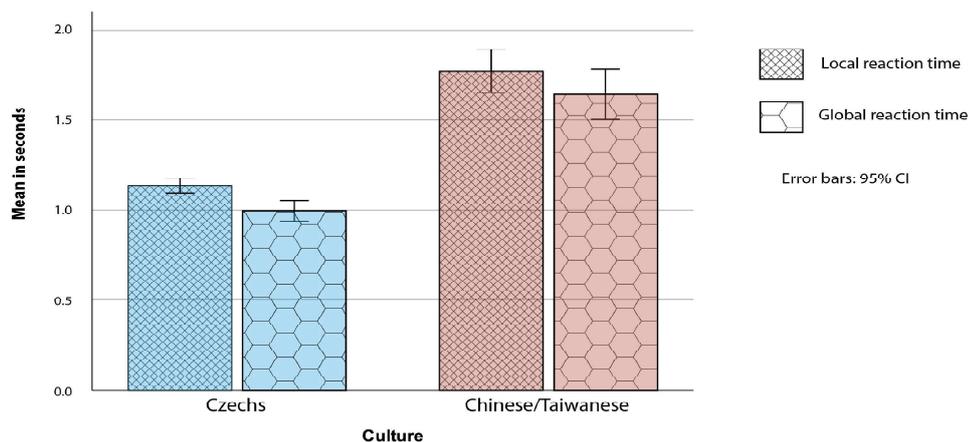


Figure 8 CFT – mean reaction times

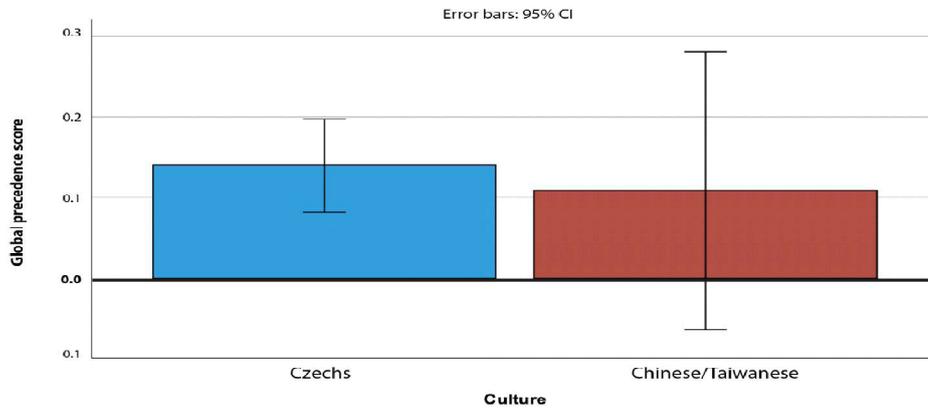


Figure 9 CFT – Mean global precedence scores (higher values mean higher global precedence)

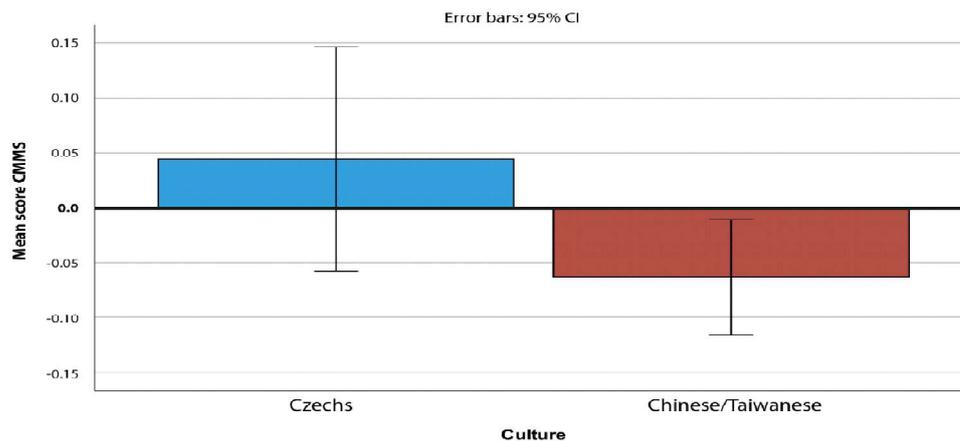


Figure 10 CMMS – Cross-cultural differences in map categorization (High value = analytic, low value = holistic).

because absolute scores were higher for both Czechs ($M = .461$, $SD = .183$) and Asians ($M = .247$, $SD = .148$).

Relationship between Sociocultural, Perceptual and Cognitive Factors

We performed a Spearman partial correlation and a path analysis (type of SEM) to verify the

research model at individual level in order to obtain an improved and deeper understanding of the phenomena under scrutiny and their mutual relationships.

Using a non-parametric Spearman partial correlation with culture as control variable, only weak correlations were found between the CMMS scores and the CFT global reaction times ($r_s = .222$, $p = .035$) and between the

CMMS scores and the CFT global precedence scores ($r_s = -.216, p = .040$). The whole correlation matrix is shown in Table 2:

A path analysis was also performed using the expectation–maximization (EM) method to estimate missing values and an asymptotically distribution-free (ADF) method, which is adequate for non-parametric data. Since both cultures were analyzed together, culture was used as a “control variable”. Two models were analyzed: Model 1 comprised CFT reaction times, and Model 2 was computed with the

calculated CFT global precedence score (Figure 11). Both models showed a very good fit (Table 3).

Path analysis for Model 1 revealed a weak direct effect of individualism (IISS independent self-construal scale) on CFT local reaction times ($\beta = -.250, B = -.167, p = .003$) and a weak direct effect of collectivism (IISS interdependent self-construal scale) on CFT global reaction times ($\beta = -.196, B = -.135, p = .047$). The higher score in individualism therefore indicated a quicker reaction time in the local

Table 2 Spearman partial correlation matrix

	1.	2.	3.	4.	5.	6.
1. Individualism	–					
2. Collectivism	.155	–				
3. CFT local RT	.002	.073	–			
4. CFT global RT	-.026	-.140	.564**	–		
5. Global precedence score	.125	.183	.176	-.546**	–	
6. CMMS	.066	.147	-.063	.222*	-.216*	–

Note. * $p < .05$, ** $p < .001$

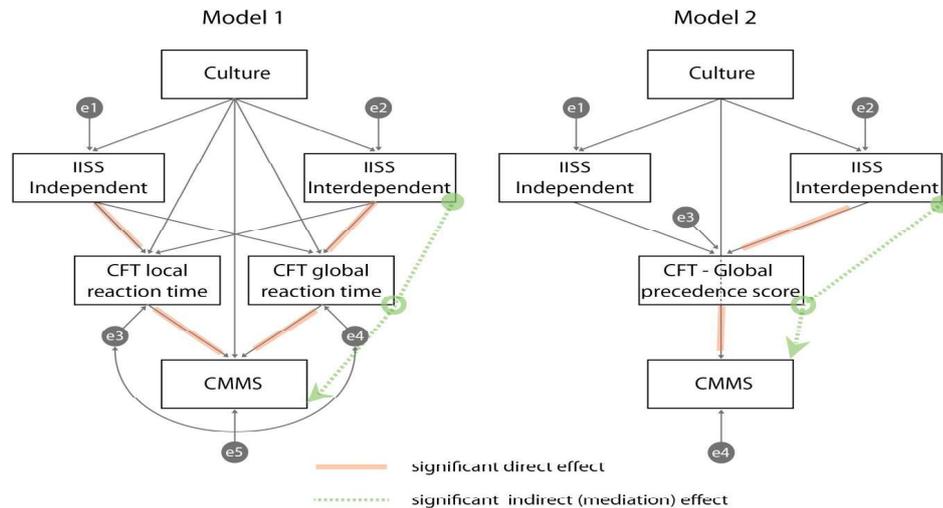


Figure 11 Path analysis models – Model 1 (left), Model 2 (right)

Table 3 *Models fits*

<i>Model</i>	<i>Chi-square</i>	<i>p-value</i>	<i>CFI</i>	<i>RMSEA</i>	<i>AIC</i>	<i>BIC</i>	<i>ECVI</i>
<i>Model 1</i>	$\chi^2(3) = 3.897$.273	.995	.057	39.897	85.289	.438
<i>Model 2</i>	$\chi^2(3) = 4.435$.218	.960	.073	28.435	58.697	.312

task, and the higher score in collectivism indicated a quicker reaction time in the global task, i.e., I/C scores weakly predicted the performance in CFT tasks. Moderate direct effects of the CFT global reaction times ($\beta = .713$, $B = .450$, $p < .001$) and the CFT local reaction times ($\beta = -.776$, $B = -.521$, $p < .001$) on the CMMS scores were also found. These results suggest that the analytic perceivers (persons with a quicker CFT local reaction time) tended to use an analytic manner of categorizing point multivariate map symbols, and that the holistic perceivers (persons with quicker CFT global reaction time) used a rather holistic manner of categorizing point multivariate map symbols. In other words, the CFT reaction times satisfactorily predicted the map categorization style. In order to estimate the indirect effects of I/C on point multivariate map symbol categorization, bootstrapping ($N = 2000$, $CI = 95\%$) was performed, and a very weak indirect (mediation) effect of collectivism (IISS interdependent self-construal scale) on the CMMS score ($\beta = -.175$, $B = -.077$, $p = .028$) was detected.

Path analysis performed on Model 2 showed a weak direct effect of collectivism (IISS interdependent self-construal scale) on the CFT global precedence score ($\beta = .357$, $B = .156$, $p = .017$). This finding suggests that collectivistic people tended to use a more global distribution of attention that is characteristic of the holistic cognitive style. A moderate direct effect of the CFT global precedence score on map categorization ($\beta = -.502$, $B = -.502$, $p < .001$) was also observed, i.e., participants who showed a relatively more global distribution of attention, categorized symbols in maps according to relatively more holistic rules, and vice versa, participants who showed a relatively more local distribution of attention, were prone

to use relatively more analytic rules of categorization. A very weak significant indirect (mediation) effect of collectivism (IISS interdependent self-construal scale) on map categorization ($\beta = -.179$, $B = -.078$, $p = .026$) was also found after bootstrapping ($N = 2000$, $CI = 95\%$).

It should be noted that we reported only significant relationships. However, as shown in Figure 11, we included all plotted relations in the models (i.e., IISS independent on CFT global RT and IISS interdependent on CFT local RT in Model 1 and IISS independent on CFT global precedence score in Model 2). Moreover, we also performed indirect (mediation) effect of individualism (IISS independent self-construal scale) on map categorization with no significant results in both models. The exogenous control variable "culture" had statistically significant and large regression coefficients on all endogenous variables in the models. Nevertheless, we did not report these results because we added it to our models only in order to weaken the influence of other variables. Moreover, the apparent dissension between insignificant correlation coefficients and significant regression coefficients of path analysis could be explained by suppression effect and Simpson's paradox (see MacKinnon, Krull, & Lockwood, 2000; Tu, Gunnell, & Gilthorpe, 2008), which postulates that a more complex statistical model can reduce, reverse or even enhance the relationships between variables.

Discussion

The aims of the presented study were: 1) to compare I/C and A/H cognitive styles and map categorization in Czech and East Asian (Chinese/Taiwanese) university students, and 2)

to investigate and verify the theoretical model of relationships between I/C and A/H cognitive styles and between A/H cognitive styles and their behavioral manifestation in the process of map categorization.

The results suggest that the Czech participants showed a significantly lower level of collectivism (interdependent self-construal scale) than did the Chinese/Taiwanese participants and a similar level of individualism (independent self-construal scale). Our results partly support the current theory that describes the West as relatively less collectivistic than the East (Hofstede, 1983; Markus & Kitayama, 1991; Nisbett et al., 2001; Triandis & Gelfand, 1998). Furthermore, a similar level of individualism corresponds to the empirical research in I/C in post-communist countries (Kolman et al., 2003; Varnum et al., 2008) and even with previous research in I/C in Czechia (Bartoš, 2010; Čeněk 2015). This finding also supports the claims of rapid individualization in the young East Asian populations (e.g., Moore, 2005; Steele & Lynch, 2013).

The results of the CFT show that all of the participants performed the global tasks more quickly than the local tasks, which is consistent with previous findings (Navon, 1977). However, our participants were generally slower compared to the original study (Navon, 1977). This fact was most probably caused by the way of responding (mouse click instead of keyboard buttons) because mouse response process has in contrast with keyboard response process one extra step (i.e., moving the mouse cursor above the response option). Our results also indicate cross-cultural differences in the general reaction times of CFT stimuli processing. The Czech participants were significantly quicker in both the global and local tasks. However, as mentioned above, these differences in reaction times demonstrated rather differences in the emphasis that both groups placed on the speed than differences in cognitive style (Kukaňová, 2017; Yates et al., 2010). The comparison of the global precedence scores (calculated from CFT global and local reaction times) showed no differences in global/local processing between

the Czechs and Chinese/Taiwanese, which was contrary to our expectations. The results of the CFT could be seen as a contradiction to the notion of the “analytic West” and “holistic East” (Nisbett et al., 2001; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). However, it is still not clear whether Central Europeans count as the “analytic West”. For example, Varnum et al. (2008) showed that Central European post-communist countries are relatively more holistic in their patterns of attention than Western Europe. Other empirical research, comparing the sensitivity to the context of Czech vs. Czech Vietnamese (Čeněk, 2015), and Czech vs. Chinese (Stachoň et al., 2018, Stachoň et al., 2019), reported mixed or contradictory results in terms of the expected differences in cognitive style.

The results of the CMMS show that the Czech participants categorized more analytically in maps, whereas the Chinese/Taiwanese categorized more holistically. This result agrees with the theory that Westerners use slightly more analytic categorization patterns and Easterners use more holistic categorization (Chiu, 1972; Ji et al., 2004; Norenzayan et al., 2002). However, the effect size of this significant difference was relatively small.

Path analysis was used to test the validity of two structural models of relationships between the variables of interest. Both evaluated models (CFT local and global reaction times and the global precedence score) showed a satisfactory good fit. The results of the path analysis show that I/C is a weak predictor of the level of global/local distribution of attention, i.e., collectivist persons tended to use a holistic cognitive style, and individualistic persons tended to use a rather analytic cognitive style. These findings partly support the theory of holistic and analytic cognitive styles (Nisbett, 2003; Nisbett et al., 2001; Triandis & Gelfand, 1998), although the values of the path coefficients were relatively small. The path analysis also did not find all of the expected direct and indirect effects of I/C on the scores of the CFT and the CMMS. The aforementioned findings were, therefore not a conclusive argument to support the A/H cognitive style theory in cross-

cultural context (cf. Nisbet et al., 2001). As with several other studies that did not find any relationship between I/C and A/H cognitive style (e.g., Davidoff et al., 2008; McKone et al., 2010; Takano & Osaka, 1999), it may be possible that this relationship could be different from what researchers expect, or perhaps even non-existent. Our findings of unconvincing yet significant relationships could also be explained in theoretical arguments, which maintain that the I/C and A/H cognitive styles only manifest at a cultural (i.e., cross-cultural comparison) not individual level (i.e., SEM and path analysis; cf. Na et al., 2010). Nevertheless, we would like to emphasize that the sample size was, in this case, relatively inadequate for SEM, therefore its results should be understood as only exploratory.

The concept of I/C and its measurement with self-report scales have recently been subject to disagreement from many scholars. This criticism mainly cites the lack of concurrent, discriminant and construct validity, insufficient conceptualization, a reductionist and dichotomous approach and insufficient psychometric characteristics in questionnaires (for review, see Levine et al., 2003; Matsumoto, 1999; Oyserman et al., 2002; Vignoles et al., 2016). For example, if the individual level of I/C can be significantly influenced by priming, then it means that I/C is not as stable in time as it is generally assumed (Gardner, Gabriel, & Lee, 1999; Oyserman & Lee, 2008). Moreover, according to the results of meta-analytical studies and systematic reviews, the West should not be described as strictly individualistic nor the East as purely collectivistic (Levine et al., 2003; Oyserman et al., 2002; Takano & Osaka, 1999; Takano & Osaka, 2018). Most recently, for example, Hakim et al. (2017) compared the levels of individualism and collectivism of American and Asian international students and found, contrary to expectations, that Americans were significantly more collectivistic, whereas the Asian students were significantly more individualistic.

Path analysis also found that global/local distribution of attention had a moderate predictive power on categorization in both of the

tested models, i.e., analytic perceivers (defined by the CFT global precedence score) used analytic categorization in maps, whereas holistic perceivers used holistic categorization. This finding is consistent with the research theory (Chiu, 1972; Ji et al., 2004; Norenzayan et al., 2002) and the empirical research (Kubiček et al., 2016; Šašinka et al., 2018; Stachoň et al., 2019). Consequently, the cognitive style that is characterized as a perceptual process is presumably manifested in higher cognitive processes, such as map reading and categorization.

Conclusions

The article describes cross-cultural differences in western and eastern cultures, between Czech and Chinese/Taiwanese university students, respectively. The theoretical background of the research was based on the theory of analytic and holistic cognitive styles and the dimensions of individualism and collectivism. Two main objectives were defined: first, to identify the possible cross-cultural differences and similarities between Czechs and Chinese/Taiwanese, and second, to verify the entire research model and the relationships between A/H cognitive style and I/C at individual levels. For this purpose, we also developed a new method (CMMS) in order to study how A/H cognitive style was manifested during categorization in map reading. The results suggest that cross-cultural differences exist between both cultures, especially at the level of collectivism (Czechs were less collectivist than the Chinese/Taiwanese) and categorization in map reading (Czechs used more analytic and less holistic categorization). Neither individual differences (e.g., SES, gender, age) nor differences in cognitive style measured by the CFT between Czech and East Asians were found. The findings also indicate that I/C is a weak predictor of A/H cognitive style and that A/H cognitive style moderately predicts categorization in map reading.

These results contradict the East-West dichotomy and suggest that the culture of Central Europe (specifically Czechia) is much more

similar to the East than expected from the literature. However, more cross-cultural research of typically Western, typically Eastern and Central European cultures is needed for an improved understanding of the real influence of culture on human perception and cognition in regions outside the East-West dichotomy. Based on the presented results, future research should focus on verification of Nisbett's (2001) vs. Kozhevnikov's (2014) models of cognitive styles. Above all, specify the number of cognitive style families, investigate the stability/flexibility of cognitive styles, and inspect the developmental aspects (e.g., children of different age) of cognitive style and its adaptive nature (e.g., research on expatriates during the process of cultural adaptation) is also suggested.

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