The Benefits of the Multicultural Mind: The Interaction between Culture and Cognitive Flexibility

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Dedication

To my grandfather, Opa Manfred (1929 - 2014), who always let me borrow his typewriter, and my grandmother, Omi Dorle (1934 - 2017), who taught me everything else.

English Abstract

This thesis seeks to investigate the potential benefits of the multicultural mind through the lens of cognitive flexibility (CF). CF is the ability to adapt to environmental change through flexible thought and behavior. Despite the centrality of CF in human adaptability, research on the topic is underdeveloped with definitions and measurement practices further creating misunderstandings. Little is known about the environmental factors which shape CF. Though bilingualism has been at the forefront of CF research, recently CF development has been hypothesized to be shaped by exposure to multiple cultures. Rigorous experimental testing has yet to take place to provide evidence for such speculations. Thus, this thesis seeks to address these gaps by 1) determining the best CF conceptual and psychometric tools across disciplines in a systematic literature review, and 2) testing the relationship between CF and culture in a multicultural population. In the systematic literature review, our sample consists of 49 articles selected from four databases. To simplify our investigation of disciplinary norms, we organized CF definitions into three theoretical frameworks: higher-order, lower order and dichotomous. We analyzed common measure features, how measure-choice aligned with CF definitions and theoretical frameworks. Analysis reveals that fundamentally different understandings of CF exist in more biologically based CF research domains (e.g., neuroscience) as compared to higher-order research domains (e.g., psychology). We propose a new unified theoretical framework we call meta-competency, to be used across CF research. In our experimental study, we hypothesized that multiple cultural environments exposure will positively predict heightened CF capacity. We compare CF performance between multicultural and monocultural individuals (N = 111) on three measures for task-switching, divergent thinking, and creativity. Our theoretical paradigm of analysis, inconsistency resolution proposes that the process of encountering cultures with different perspectives and reconciling those perspectives is how CF is strengthened in multicultural individuals. A statistical analysis using t-tests and correlations determined differences in CF performance between groups. Multiculturals showed superior performance compared to monoculturals on CF measures, though not significantly. Multicultural performance was significantly different on one task: the number component of the task-switching measure. Lack of significant findings may be due to small sample size and limitations in recruiting our ideal population sample; multicultural and monocultural samples may have been too heterogeneous.

Our results nevertheless suggest higher inconsistency resolution, rather than language switching, to be a pathway for CF strengthening. Overall, despite irregularities in current CF measures and definitions, as well as competing hypotheses about the environmental factors shaping CF, our systematic literature review and study suggest higher CF may stem from multicultural individual's ability to integrate multiple cultural models. Our research may shed light on new ways to strengthen CF that offer protection against mental health illnesses and cognitive rigidity. Future research could refin this study paradigm through testing across different ecological settings. In addition, more nuanced higher-order CF measures could be developed to quantify an individual's ability to assess situations through multiple cultural lenses.

Keywords: Cognitive Flexibility, Culture, Conceptualizations, Measures, Inconsistency Resolution, Systematic Literature Review, Theoretical Framework

Résumé

Cette thèse cherche à étudier les avantages potentiels de l'esprit multiculturel à travers le prisme de la flexibilité cognitive (FC), la capacité de s'adapter aux changements environnementaux grâce à des pensées et comportements. Malgré la centralité de la flexibilité cognitive dans l'adaptabilité humaine, la recherche sur le sujet est peu développée avec des définitions et des pratiques de mesure créant davantage de malentendus. On sait peu de choses sur les facteurs environnementaux qui façonnent la flexibilité cognitive. Bien que le bilinguisme ait été à la pointe de la recherche sur la flexibilité cognitive, il a récemment été suggéré que le développement de la flexibilité cognitive a été façonné par l'exposition à plusieurs cultures. Des tests expérimentaux rigoureux n'ont pas encore eu lieu pour fournir des preuves pour ces spéculations. Ainsi, cette thèse cherche à combler ces lacunes en déterminant les meilleurs outils conceptuels et psychométriques de la FC dans toutes les disciplines grâce à une analyse systématique de la littérature, et en testant la relation entre la FC et la culture dans une population multiculturelle. Dans la revue systématique de la littérature, notre échantillon contient 49 articles sélectionnés dans quatre bases de données. Pour simplifier notre enquête sur les normes disciplinaires, nous avons organisé les définitions des FC en trois cadres théoriques : d'ordre supérieur, d'ordre inférieur et dichotomiques. Nous avons analysé les caractéristiques communes de mesure, comment le choix de mesure s'aligne sur les définitions de la FC et les cadres théoriques. Notre analyse révèle que des compréhensions fondamentalement différentes de la CF existent dans différents domaines de recherche biologiques (p. ex., neurosciences) par rapport aux domaines de recherche d'ordre supérieur (par exemple, la psychologie). Nous proposons un nouveau cadre théorique unifié que nous appelons méta-compétence, pour être utilisé dans l'ensemble de la recherche sur la mucoviscidose. Dans notre étude expérimentale, nous avons émis l'hypothèse que l'exposition à des cultures différentes prédira positivement une capacité accrue de FC. Nous comparons la performance entre des individus de plusieurs cultures et d'une seule culture ($N = 111$) sur trois mesures pour le changement de tâche, la pensée divergente et la créativité. Notre paradigme théorique d'analyse propose que le processus de rencontre et de conciliation de plusieurs cultures est la façon dont la FC est renforcée dans le multiculturalisme. Une analyse statistique utilisant des tests t et des corrélations a déterminé les différences de performances entre les groupes. Le groupe multiculturel a montré des

performances supérieures par rapport au groupe monoculturel sur les mesures de CF, mais pas de manière significative. La performance multiculturelle était significativement différente sur une tâche: la composante numérique de la mesure de changement de tâche. Le manque de résultats significatifs peut être dû à la petite taille de l'échantillon et aux limites du recrutement de notre échantillon de population; les échantillons multiculturels et monoculturels étaient potentiellement trop hétérogènes. Nos résultats suggèrent néanmoins qu'une résolution d'incohérence plus élevée, plutôt qu'un changement de langue, est une voie pour le renforcement des FC. Dans l'ensemble, malgré des irrégularités dans les mesures actuelles de la FC et des définitions, ainsi que des hypothèses concurrentes sur les facteurs environnementaux qui façonnent la FC, notre revue systématique de la littérature et notre étude suggèrent que la FC plus élevée peut provenir de la capacité de l'individu à intégrer de multiples modèles culturels. Nos recherches pourraient démontrer de nouveaux moyens de renforcer la FC qui offrent une protection contre les maladies mentales et la rigidité cognitive. Des recherches futures pourraient valider ce paradigme d'étude en testant différents aspects écologiques. De plus, des mesures de FC d'ordre supérieur plus nuancées pourraient être élaborées pour quantifier la capacité de l'individu à évaluer les situations à travers de multiples lentilles culturelles.

Mots-clés : Flexibilité cognitive, Culture, Conceptualisations, Mesures, Incohérence Résolution, Revue systématique de la littérature, Cadre théorique

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Contribution of Authors

The introduction, discussion and conclusion of the thesis were written by Pascale with the guidance of SV and MW. The author contributions for the manuscripts are listed separately. All of the manuscripts included in this thesis are currently unpublished.

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I Chapter: Introduction

Stonequist's famous publication, *Marginal Man* in 1937, was the first to cement the academic belief that individuals with multiple cultural backgrounds are bound to suffer psychological distress. Specifically, Stonequist believed they were perpetually suspended between two cultural worlds and therefore never fully belonged. Multiculturals' burden and complexity of managing dual identities and reference points were inevitably seen to cause undesirable internal and external conflict (as seen in LaFromboise, et al., 1993). Phinney (1999) described this psychological conflict emerging *within themselves* due to the dissonance between different cultural values, attitudes, and expectations (as seen in Nguyen & Benet-Martínez, 2007).

However, DuBois (1961) was the first to argue against such fatalistic notions and claimed multiple cultural identities could confer psychological advantages. DuBois saw bicultural individuals as having an upper hand due to their *double consciousness,* or simultaneous awareness of two or more cultures. DuBois's *double consciousness* was hypothesized to develop due to multicultural's need to mediate their words, thoughts, and behaviour in culturally congruent ways (Bhawuk & Brislin, 1992 as seen in Crisp & Turner, 2011). Thus, allowing multiculturals to become "perspectivist in their analysis of behaviour" (Crisp & Turner, 2011) and learn to evaluate situations from several cultural viewpoints.

Thus began the debate on whether multicultural lifestyles are psychologically beneficial or detrimental (Tadmor et al., 2009). However, only lately have psychologists begun to examine how the management of this *double consciousness* effects executive functioning (Benet-Martinez et al., 2002). There is evidence to suggest that cognitive control processes (Tran et al., 2019), in particular, creativity and problem-solving, are improved by cultural experiences (Leung & Chiu, 2010). The essential cognitive ability and characteristic underlying creativity and problem-solving is seen as *cognitive flexibility* (Ritter et al., 2014). *Cognitive flexibility* (*CF*) is considered a key hallmark of human cognitive function (Jacques & Zelazo, 2005), and is defined as facilitating "multitasking and finding novel, adaptable solutions to changing demands" (Ionescu, 2011). "Immersion into dissonant cultures" is shown to promote *cognitive flexibility* (Spiegler & Leyendecker, 2017) and holds the most promise in explaining the psychological adaptability of multiculturals (Han et al., 2016). Thus, the focus of this thesis will be to analyze the relationship between multicultural experiences and CF.

1.1. Terminology

1.1.1. Multicultural

Over the last 40 years, the term *multicultural* has acquired different meanings. But before we can define *multicultural*, we must first and foremost, define culture. Culture can be understood as group-

specific knowledge and practices that form "a shared meaning system" (Legare, 2019). These shared meaning systems allows individuals to form similar interpretations of their social environments and facilitates social coordination (Chao et al., 2015). Culture also influences how individuals "constitute *the self"*: i.e., who they understand themselves to be (Markus & Kitayama, 2010). Being *multicultural* thus means having several different shared meaning systems and constitutions of the self (i.e., cultural identities). For the purposes of this thesis, we further refine this term to refer to individuals who have lived outside their country of birth for a significant portion of their developmental years (Moore & Barker, 2011). Through this definition our aim is to capture individuals who had distinct intercultural experiences during their childhood and consequently acquired multiple diverse cultural perspectives and identities (Moore & Barker, 2011). Our research aim is novel as the little research on the topic of culture on cognition that currently exists focuses on individuals with two (dual) cultural models. In contrast, our research strives to assess individuals with *multiple* cultural models (more than two). Due to the disparity in research on our specific topic of interest (i.e., cognitive effects of multiple cultural models), we will use the terms *dual* and *multiple* interchangeably throughout the literature reviews included in this thesis.

1.1.2. Cognitive Flexibility

CF is defined as a skill that enables strategic adaptation to environmental change through flexible thought and behaviour (Barbey, et al., 2013). Analyzed from the perspective of multicultural experiences, CF is hypothesized to allow individuals to integrate new social rules in cultural environments because confers three skills. Namely it allows individuals to: "(a) quickly and effortlessly switch between cognitive strategies and semantic categories, (b) integrate distant and conflicting ideas, and (c) widen their creative idea base" (Gocłowska & Crisp, 2014). In this thesis, because CF is a multifaceted concept, we specifically define CF as a *meta-competency* enabling general flexible behavior through both *lower order* and *higher order* elements (Ionsecu, 2011). We define *lower order CF* as skills related to executive control such as attentional and task shifting. We define *higher order CF* as a skill related to more abstract cognitive abilities such as creativity and problem-solving. Through this *meta-competency* framework, each of the skills associated with being *multicultural* can be categorized, analyzed, and understood from the correct perspective.

1.1.3. Search Terms

Due to the limited amount of research using the constructs *CF* and *multicultural*, in both the systematic review and empirical studies we supplemented our literature reviews with research on other closely related constructs. This inclusive approach towards our literature reviews was also necessary because both CF and multiculturalism are multifaceted concepts with divergent interpretations. For *CF*

we took the constructs *creativity, insight, divergent thinking,* and *problem-solving,* to be subsets of *higher order CF* (DeYoung et al., 2008). Similarly, we also took the constructs *task-switching* to be subsets of *lower order CF.* For the *multicultural* construct, we took *bicultural, third culture kid, immigrant,* and *expatriate,* to be subsets of multiculturalism.

1.2. Background of the Study

Research on exposure to multicultural environments and psychological functioning has shown multiculturals to have numerous cognitive processing advantages. These cognitive advantages are hypothesized to emerge due to how highly cognitively demanding the experience of being immersed in two distinct cultures is (i.e., cultures whose values are very different from one another) (Spiegler & Leyendecker, 2017). To appropriately adapt their behavior to suit different cultural contexts and negotiate the everyday lived experience of diversity in many different ways (Berry & Ward, 2016) they must "shift between different modes of thought" (Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009 as seen in Pringle, 2014). Consequently, individuals possessing different cultural identities were found to possess greater attentional control (Saad et al., 2013), superior creativity (Gocłowska & Crisp, 2014), and heightened visuo-spatial abilities (Bialystok, 1988; Bialystok et al., 2009; Anderson et al., 2018 as seen in Chen & Padilla, 2019). Studies show biculturals to have an enhanced capacity to construe people, objects, and ideas in a less rigid, and stereotypical way, compared to individuals with only one internalized culture (Crisp & Turner, 2011). This more individuated way multiculturals process information may be the result of heuristic and holistic categorical thinking being ineffective in diverse socio-cultural environments. Studies also found multiculturals to be more likely to explain behavior through an interaction effect between situational (i.e., environmental) and dispositional (i.e., psychological) factors (Verkuyten & Pouliasi, 2002). Thus, multiculturals are known to be "highly informed perceivers" (Crisp & Turner, 2011), with superior abilities to detect cultural meaning (Benet-Martínez et al., 2006). This advantage may stem from their need to form complex representations of social situations through deeper, more detailed, and systematic information-processing. Overall, these cognitive advantages suggest multicultural experiences to strengthen cognitive processes related to flexible perception, categorization, attribution, and adaptation (i.e., CF).

1.3. Problem Statement

However, rather than ascribe the superior ability to flexibly adapt to novel demands (i.e., CF) to the cultural aspect of multicultural experiences, much of research attributes these executive functioning advantages to bilingualism (Becker et al., 2015; Hsieh, 2012). Researchers promote the idea that the superior selective attention required to control rapid back and forth switching between languages, gives

bilinguals flexible mindsets (i.e., superior CF) (Poulin-Dubois et al., 2010; Hommel et al., 2011). Yet, in a study comparing CF performance on a task-switching paradigm between bilinguals and monolinguals, CF advantages for the bilingual group were shown to be both task and sample specific (Ross & Melinger, 2017). That is to say, the bilingual CF task advantage was not replicated in other bilinguals and did not correlate with superior performance on other CF tasks. These results may be due to bilingualism requiring the inhibition of irrelevant information, an aspect of lower order CF, but not higher order CF. Thus, evidence reveals mixed findings that language switching is the mechanism through which *cognitive flexibility* and cultural adaptability are improved (Haft et al., 2019). Instead, it seems that bicultural experiences, which involve very different skillsets to bilinguals, are responsible for the strengthening of creativity and problem-solving abilities (Spiegler & Leyendecker, 2017). This may be because switching between languages requires inhibition, whereas switching between different cultural frameworks requires individuals to resolve dissonance between discordant cultural values (Spiegler & Leyendecker, 2017). Thus, we suspect this repeated resolution of cultural conflict is the true mechanism through which cognitive flexibility is increased in multiculturals. This process is called *schema violation* (Ritter et al., 2014) and refers to encounters with situations which contradict an individual's beliefs and expectations (i.e., schemas), requiring individuals to alter their worldview to accommodate their new knowledge (Piaget, 1971, 1975 as seen in Gocłowska & Crisp, 2014). While this is a normal developmental stage for all children, individuals with dual (or multiple) cultural identities continue to integrate conflicting schemas throughout their lives at a much higher rate than monocultural individuals (Gocłowska & Crisp, 2014). Research has found that the negotiation of multiple cultural perspectives and individual's own multiple identities to lead to greater CF (Gocłowska & Crisp, 2014). This cognitive process at play during *schema violations* is called *inconsistency resolution* and refers to the reconciliation between differences between perspectives. However, little empirical evidence exists to support CF advantages through this *inconsistency resolution* mechanism in multiculturals.

1.4. Structure of Thesis

Although both advantages and detriments of multicultural lifestyles for cognitive and psychological functioning have been reported, in this thesis we hope to put forward an argument for the cognitive *benefits* of multicultural experiences. Specifically, we seek to further knowledge on CF in multiculturals' through two distinct studies: a systematic literature review and an empirical study. The systematic review aims to investigate which CF terms, definitions, and measures currently exist. The empirical study aims to empirically explore the relationship between exposure to multiple cultural environments and both *higher* and *lower order CF*. While both studies were conducted concurrently, for

the sake of conceptual flow we decided to present the systematic review first to allow the reader to familiarize themselves with the key concepts and measures discussed throughout this thesis.

Our motivation for the systematic review stems from CF "still being a poorly understood construct" (Ionescu, 2011). Researchers currently define CF in multiple ways; some see CF as a specific skill, (e.g., set shifting) while others perceive CF as a property of cognitive functioning (Colzato et al., 2009; Blaye & Bomthoux, 2001; Plunkett, 2006; Deak, 2003 as seen in Ionescu, 2011). The vast variety of CF definitions across disciplines make it difficult to understand how to best conceptualize CF in the context of multicultural cognition. This ambiguity in CF definition has also led to a lack of clarity in the CF research field concerning operationalization. Currently there are four dozen cognitive and socio-cognitive tasks circulating that are considered flexibility measures (Jacques et al., 2005). All of "these tasks vary greatly in the information and domain they were specifically designed to assess" (Jacques et al., 2005). We are hopeful that a systematic review will be able to increase clarity on both conceptualization and measurement as there has recently been a reinvigorated research effort on the CF construct. A 2019 search of the term in literature databases supposedly yielded 'more than 3000 results on PsycINFO, with approximately 1,500 in the last five years alone' (Yu et al., 2019). Consequently, through our systematic review we aim to gain knowledge on which measures are sensitive to working with cultural populations. As well as gain clarity on the best way to define and assess the *higher order CF* benefits multicultural experiences have been known to confer. We intend to put forward a new framework to unifying future CF research.

Our motivation for our empirical study is based on an experimental pilot study we ran during an honors thesis to investigate whether a correlation exists between multiculturalism and CF. The pilot study revealed a positive correlation to exist between multiculturalism and both higher and lower order CF measure, though not significantly. As such we now wish to test the same study paradigm with a larger sample size to see if the effects replicate and a significant effect may be found.

1.5. Summary

In the research community, opinions are split on whether multicultural experiences confer cognitive and psychological advantages or challenges. Some researchers argue that a completely integrated bicultural identity is the most optimal model and produces numerous advantages across many domains of life (Berry, 1997; Phinney et al., 2001). In contrast, other researchers argue multiculturalism is inherently dysfunctional and flawed because it results in social stress and isolation (Rudmin, 2003; Vivero & Jenkins, 1999 as seen in Nguyen & Benet-Martínez 2007). In this thesis we argue that

multicultural experiences confer distinct benefits for both individuals and societies due to the cognitive flexibility strengthening they allow. Furthermore, we believe that because CF is "a general characteristic of cognition and therefore a property of various cognitive processes" (Ionsecu, 2011) CF is applicable to a wide range of research domains. Consequently, CF is a highly valuable subject for research because it is sensitive enough to be shaped by psychosocial environments, yet robust enough to be considered an "indissociable components of cognitive control" (Edwards et al., 2018). Studies have even suggested that higher intelligence is accompanied by a higher degree of flexibility (Colzato et al., 2006). Thus, CF is a mental capacity that may form the perfect bridge to explore the connect environmental exposure and overarching cognitive traits. Hopefully, our investigation on the benefits of the multicultural mind will reveal the deep importance of socio-cultural experiences for cognitive and psychological functioning.

II Chapter: Manuscript 1

Definitions and Measures of Cognitive Flexibility: A Unified Framework for Cognitive Flexibility as a Meta-Competency

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Author contributions. PB designed the study and database search strategy, collected data, screened articles, analyzed data, wrote the introduction, methods, and discussion. PB edited the results section. AM assisted with the study design, article screening, data collection, and theoretical conceptualization of the introduction. TD assisted in the data collection, data analysis, and wrote the conceptual portion of the results. JC assisted in screening articles, analyzing data and performed a descriptive analysis on measures. EF assisted in data analysis of the measures, wrote the measure's portion of the results, and provided feedback. EF, TD and PB conceptualized, and formatted the results tables together. SV supervised PB and assisted in the study design, theoretical conceptualization and provided feedback on the manuscript. KL offered feedback on the manuscript draft.

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Abstract

Introduction. A multiplicity of definitions of the *cognitive flexibility* (CF) construct across disciplines jeopardizes the ability of researchers to compare, consolidate, and progress research. This article aims to present a systematic review of each discipline's (e.g., psychology, neuroscience, linguistics) usage of CF definitions and measures by examining all relevant studies published between 1970 and 2020.

Methods. The systematic review was conducted according to PRISMA guidelines using the online review platform COVIDENCE. We retrieved papers (N= 49) from five research databases: Ovid MEDLINE, EMBASE, PsycINFO, and Scopus. To simplify our investigation of the divergence in disciplinary usage, by organizing CF definitions into three theoretical frameworks: higher-order, lower order and dichotomous. The higher-order framework includes CF processes that require more global, complex, cognitive functions such as creativity, category-generation, and social adaptability. The lower-order framework includes more simplistic CF processes, dependent on executive functioning such as processing speed, task-switching, and attention. The dichotomous framework includes both higher-order and lower-order CF capacities.

Results. Only a few papers provide definitions of CF, the majority of which are lower-order definitions with the most common being *attentional switching.* The most common measures of CF are vigilance-based. This trend in CF definition and measurement stems from biological disciplines (e.g., neuroscience).

Conclusion. Based on these findings, we propose an overarching framework of CF to unify conceptualizations across different disciplines. This framework, *meta-competency,* defines cognitive flexibility as a heterogeneous cognitive function, dependent on both higher and lower order cognitive mechanisms. The framework also includes a proposal for researchers to establish a common CF taxonomy. This *meta-competency* paradigm may allow researchers to assess different components of CF more accurately both conceptually and psychometrically. Our review encourages a more complex understanding of CF and provides a theoretical structure to unify the CF concept.

Keywords: Cognitive Flexibility, Theoretical Framework, Conceptualization, Measurement, Discipline, Meta-Competency

1. Introduction

Cognitive flexibility (CF) is a cognitive function enabling human adaptability. Although it is a construct employed across diverse disciplines, it lacks clear definitions and measures. Thus far, the CF construct has allowed researchers from psychology, neuroscience, linguistics, and developmental psychology to explore many aspects of human adaptive functioning. For example, psychologists have investigated the role of CF in mental illnesses such as depression (Fazeli et al., 2015), and anorexia (Tchanturia et al., 2004). Neuroscientists have used CF measures to determine cognitive functioning capacity in patients with traumatic brain injury (Lucas et al., 2020), and Alzheimer's disease (Traykov et al., 2007). Linguists have researched the role of CF in a bilingual's ability to rapidly switch between two languages (Ibrahim et al., 2013). In developmental research, the role of CF in the reduction of social bias (Singh et al., 2021), the formation of theory of mind (Gocłowska & Crisp, 2014), and socio-cultural adjustment (Jacques, 2005). Though the presence of CF across such a range of disciplines speaks to its versatility and utility as a construct, it also introduces some inherent flaws. Due to the foundational perspectives of each discipline, CF definitions and theories often contain implicit assumptions (Remler & VanRyzin, 2015). As a result, the CF research field seems to be struggling from a multiplicity of fragmented definitions. Consequently, ambiguity exists around what the construct *cognitive flexibility* means. So far, few theoretical or review articles have been published on the CF concept - an important gap targeted by the present article.

1.1. Background

Two factors underpin the disjointed understanding of CF in the research community. First, there is the illusion that it is an intuitive and self-explanatory concept. This implicit usage of the construct seems to have caused the term to lack clear conceptual boundaries. Further, the literature exhibits a lack of convergence in the understanding of CF across multiple domains that implicate flexibility: multi-tasking, bilingualism, problem-solving, creativity, insight, and adaptive behaviour (Barbey, et al., 2013). The term CF seems to have been given many different definitions across different domains and disciplines (Ionescu, 2012). Overall, the multiplicity and ambiguity of the CF construct seem to impede researchers' ability to discuss and compare the scientific findings produced under the title CF both within and between disciplines.

1.2. Research Problem

Several authors have recognized this problem within the CF field and sought to advance research by proposing their own definitions of CF. However, as their CF definitions stem from the academic norms of their own discipline, such definitions often fail to provide a structure to integrate CF constructs across disciplines. Barbey, Colom, and Grafman (2013) emphasize the CF field would profit from pinpointing key adaptive responses and their relation to a broad variety of cognitive, emotional, and social processes (Barbey, et al., 2013). Ionescu, (2012) states that although the term CF has allowed a considerable quantity of knowledge to be amassed under the same construct, there is a lack of in-depth and consolidated description of cognitive flexibility which has hindered progress in the field.

1.3. Research Aim

Our review aims to address this issue by cataloguing how researchers define and measure CF across disciplines. Next, we aim to present an overarching theoretical framework to unite CF research. We hope this theoretical framework for CF will help cement an integrated understanding of the concept.

1.4. Hypothesis

We hypothesized that neuroscientific definitions and measures of CF would be the most robust and prevalent. Our hypothesis stemmed from an awareness that disciplines with more of a biological basis have the advantage of studying CF through objective tasks and measures

1.5. Method

1.5.1. Database Search Strategy

We selected articles that performed quantitative CF research on both adults and children published in peer-reviewed journals between 1970 and 2020. We accessed articles indexed in SCOPUS, PsycINFO, Ovid Medline, and Embase. To classify the complete range of usage and definitions, we did not predetermine what terminological definitions would count as *cognitive flexibility* in our article selection for this review. Rather, we included any article employing the term *cognitive flexibility* or its related synonyms: flexible thinking, creative thinking, mental flexibility, cognitive shifting, task shifting, task switching, mental set-shifting.

1.5.2. Study Design

First, we catalogued the researcher's conceptual definitions of CF into three theoretical frameworks: lower-order (LO), higher-order (HO), and dichotomous (DI). We sought to understand nuances within each perspective to access the homogeneity of CF understandings within each field. Second, we recorded the different terms used to refer to the CFconstruct, along with conceptual definitions. Third, we examined the measures used to capture CF along with the conceptual definitions they were most frequently used with. We also aimed to examine differences between CF definitions and measures in cultural and non-cultural research contexts spanning across disciplines.

1.5.3. Theoretical Framework

The LO framework describes a subordinate level of flexible behaviour controlled by subcomponents of the executive functioning system (i.e., a set of processes that facilitate goal-directed behaviour [18, 42]). The HO framework describes a superordinate level of flexible behaviour mediated through interactions between different cognitive systems. The DI framework describes both lower and higher-order CF as two distinct types of CF. These frameworks were inspired by the definitions used for CF in Ionescu's 2012 paper. We hope that the frameworks we identify through our review could help standardize scientific approaches to researching CF and increase the utility of the CF construct for many research disciplines.

2. Methods

2.1. Search Strategy

The PRISMA diagram, Figure 1, outlines the steps taken to conduct this review from the start date, January 2020, to the end date, February 2021. Four electronic databases (*Embase, Scopus, OVID Medline,* and *PsycInfo*) were searched for articles published from the years 1970 through to 2020 inclusively. We focused our search on articles presenting both valid theories and measures of CF.

2.1.1. Inclusion Criteria

Our research sample population could include all genders and all ages. Our intervention could include all psychometric measures used to capture the CF construct. No comparative intervention studies were used in our study. This is because our aim was not to compare interventions to one another but rather to describe extant investigations. Our review encompassed published and peer-reviewed articles as well as original studies. If an article did not meet the inclusion criteria it was rejected from the review.

2.1.2. Exclusion Criteria

No constraints were placed on articles' language or country of publication. No articles were omitted due to the usage of specific terminology for the CF construct. We accepted all CF construct usage ranging from *task switching* to *mental shifting* to *flexible thinking,* etc. We excluded specific types of studies from our review: literature reviews, meta-analyses, theoretical elaboration, and dissertations.

2.2. Search Results

All articles matching our search criteria were downloaded from selected databases on June 7th, 2020. Key search terms (culture, psychological measurement, and cognitive flexibility) retrieved 284 articles: 2 articles from *Embase*, 68 articles from *Scopus*, and 214 articles *OVID Medline*. Although we searched the database *PsycInfo*, no articles were retrieved. Results yielded a total of 251 eligible articles after the removal of 33 duplicate articles.

2.3. Study Selection

We screened 100% of the 251 articles found across all four databases in our review using an online tool called *COVIDENCE.* This tool allowed for streamlining of article selection across each phase of our review between several reviewers. To minimize reviewer selection bias all title/abstract, and full-text article screening, as well as data extraction was performed by two reviewers. After screening procedures 49 articles satisfied our inclusion criteria.

2.4. Data extraction

Data extraction was performed by four reviewers through in-depth article reading. For each article, reviewers sought to determine the: term(s) used for CF, definition(s) of CF given, relevance of CF to the research question, sample population, and research discipline. The four reviewers paired off (JC and TD, AM and PB), and each pair performed data extraction on half of the articles. Each pair (JC & TD and AM & PB) independently read the same 25 articles and filled an excel spreadsheet with extracted information. Pairs of reviewers then compared their spreadsheets to reach a consensus on the findings.

2.5. Analysis of Identified Literature

Following data extraction, conceptual definitions and measures were categorized into three theoretical frameworks (Lower-Order, Higher Order, Dichotomous - LO HO, DI). We also organized articles into cultural and non-cultural contexts.

2.5.1. Conceptual Review

Two reviewers (TD, PB) independently analyzed the conceptual definitions provided in each article. Next, the reviewers compared their interpretation of each article's CF conceptualizations to reach

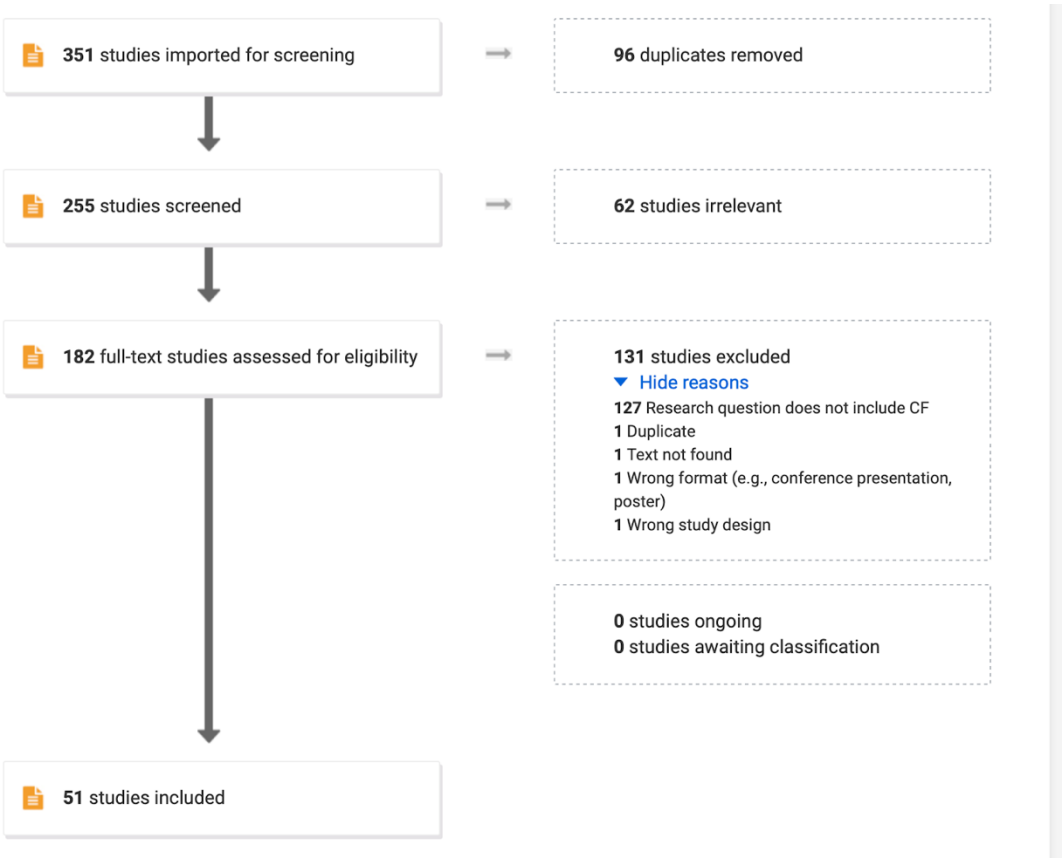
a consensus on how to categorize CF definitions. For each article reviewer's recorded: terms used to refer to CF, CF definitions, articles CF theoretical perspective, and CF definition quality (i.e., complete, partial or absent). The conceptual review's main aim was to assess the theoretical foundation underlying each author's conceptualization of CF. We classified each conceptual definition into one of three theoretical frameworks: lower-order (LO), higher-order (HO) and a hybrid perspective referred to as the dichotomous framework (DI). We then identified common elements amongst the definitions under each framework. This allowed us to create more specific CF subcategories within the theoretical frameworks. We also organized conceptual definitions from articles according to usage in cultural versus non-cultural contexts and classified them as such.

2.5.2. Measure Review

Two research assistants (JC & EF) assessed each instrument used to measure CF. Instrument summaries were written. Operational definitions were created from each instrument's summary and its associated CF definition. A second reviewer (EF) analyzed each measure's psychometric properties using terminology taken from a 2015 Psychological Testing article [17]. First, psychological measures were divided into *cognitive* and *non-cognitive* categories. Next, the cognitive and non-cognitive measures were categorized by response type: *free-response* or *recognition* (see Table 2). Furthermore, a note was made beside all articles used in cultural versus non-cultural contexts.

Figure 1

PRISMA - Flow diagram of our systematic literature review relating to the definitions and conceptualizations of CF



Note. The review was conducted during the 2020 winter and summer academic terms.

3. Results

3.1. Conceptualizations

This section focuses on terminology, conceptual definitions, and operational definitions. Conceptual definitions are the theoretical descriptions of the CF concepts. Operational definitions describe how the researchers observe or measure their conceptualization of CF in an experimental setting. This review found 33 out of the 49 articles provided some definition of CF, either complete or partial. The 15 remaining articles were devoid of CF definitions. Out of the 77 conceptual definitions identified, 20 were complete definitions and 27 were partial definitions.

3.1.2. Lower-Order Framework

The lower-order theoretical framework of CF focuses on set-shifting aspects of CF. The majority of articles reviewed ($N = 41$) viewed CF as a subset of executive functioning allowing cognitive shifts to occur between *cognitive objects*. We define a *cognitive object* as a mental item that executive functions can access, process, or interact with. Examples of *cognitive objects* include stimuli, rule sets, and mental sets. Definitions within the LO perspective belong to two subcategories. These subcategories differ in the

way articles: (1) define how the shifting happens, and (2) identify the cognitive objects involved in cognitive shifting.

Mental sets. In the first subcategory, the cognitive objects involved in the shift are mental sets. Mental sets can be problem-solving strategies, rule sets, and other cognitive categories. The exact definition of mental set usually depended on the operational definition of CF used by the authors. A portion of articles under this subcategory focuses on rule switching rather than mental sets. Rule switching is a shift from one set of rules to another to complete a cognitive task. Tasks measuring rule switching required participants to follow different rule sets within a task. Those tasks use cues to let the participant know which rule set to follow.

Attention. The second subcategory centres on attention rather than executive function, making it more specific. For this reason, we call this category *attentional shifting*. Authors define *attentional shifting* as the ability to process more than one stream of information (Sobeh & Spijkers, 2012) or more than one stimulus (Fernandez & Marcopulos, 2008). Thus, the cognitive objects involved in the shift are streams of information presented as stimuli. Sobeh & Spijkers (2012) use response times and accuracy of response to a stimulus to measure attentional shifting. Fernandez and Marcopulos (2008) use the TMT-A as well as TMT-B to measure attentional shifting. In sum, although the attentional perspective of CF departs from the way CF is typically framed in the LO perspective, its operationalizations remain similar to the way CF is operationalized in the first two subcategories of LO(i.e., when CF is defined as a subset of executive functioning).

3.1.2. Higher-Order Framework

We define *higher-order* CF as the set of complex cognitive functions that facilitate creativity, environmental and social adaptability, and fluency. We identified three perspectives on higher-order CF in this review.

Changing Perspective. This first subcategory within the HO perspective, entitled *change of perspective*, roughly describes CF as *thinking outside the box*. In this subcategory, CF is not seen as relating to any specific cognitive process. Instead, CF is seen as the ability to change one's perspective (Alavi et al, 2019; Shoghi Javan & Ghonsooly, 2018). A total of three out of the seven articles in the HO framework use the *change of perspective* CF conceptual definition.

Environmental Adaptability. The second subcategory in the HO framework is *environmental adaptability*. Tranter and Koutstaal (2008) define this perspective as the ability to change one's behaviour in response to environmental cues. In Cotrena and colleagues (2016), *environmental*

adaptability is the ability to adjust "one's behavioural strategy in response to changing environmental demands".

Generation of Categories. The third subcategory of HO framework CF conceptualizations is *category generation*. It occurs once in Tadmor and colleagues (2012), where they use the term *flexibility*. In their article, *flexibility* is seen as a component of creativity - the ability to come up with ideas in a wide variety of categories. Tadmor and colleagues measure CF using the Alternative Uses Task.

3.1.3. Dichotomous Framework

Reactive flexibility and spontaneous flexibility. Elsinger and Grattan (1993) introduce a framework for CF which includes two distinct forms of flexibility: *reactive flexibility* and *spontaneous flexibility*. This dichotomous framework (DI) is utilized in two of the articles in this review (Dalhman et al., 2013; Bellaj et al., 2016). The DI framework, therefore, represents a hybrid between the LO and the HO frameworks. *Reactive flexibility* is the ability to shift between response sets. It resembles the conceptualization of CF found under the LO theoretical framework. The second sub-category of CF is *spontaneous flexibility* and is defined as the ability to produce a diversity of ideas.

Table 1

Conceptual definitions

Conceptual definition	Term used	Quotes	Authors	Complete definition
Framework - Executive Function				
Ability to switch/shift between mental sets	*Cognitive flexibility*	"This task measures cognitive flexibility, as indexed by the ability to **maintain and switch between rule sets**."	Ross & Melinger, 2017	X
		"Much research has investigated the bilingual advantage in skills of cognitive flexibility, a key component of executive functions, which involve the ability to **shift between mental sets**."	Seçer, 2016	X
	Mental flexibility/ Cognitive shift	"Part B, in addition to all the components required in Part A, assesses with more precision the **ability to alternate between two cognitive sets of stimuli, also referred to as mental flexibility or cognitive shift,** all crucial to EF."	Constantinidou et al., 2012	X
	Set-shifting (flexibility)	"[The WCST] measures concept formation and set shifting abilities (flexibility) [...]To successfully complete this task, a person must be able to **shift cognitive set**s in order to abandon the previously correct sorting rule for the new rule."	Vega & Fernandez, 2011	X
	Switching	"Switching is defined as the ability to **shift efficiently to a new category or subcategory**, once a previous category is no longer productive."	Ross et al., 2007	X
		"**Switching between two rule sets**, as in condition C, is already manageable at 3-year-old but it is more difficult than inhibition (more errors and longer times needed)."	Rato et al., 2018	X
Attending different stimuli/attention	*Flexibility*	"Part B [of the TMT] is assumed to encompass cognitive abilities, such as **flexibility, to shift the course of an ongoing activity and the capacity to deal with more than one stimulus at a time**."	Fernández & Marcopulos, 2008	X
Framework - Dichotomous				
Two distinct forms of flexibility	*Spontaneous and reactive flexibility*	Eslinger and Grattan (1993) argued that **WCST is a measure of reactive flexibility** while **AUT measures spontaneous flexibility** and found that these two different forms of flexibility are associated with different brain structures.	Dahlman et al., 2013	
		"Based on Eslinger and Grattan's (1993) dichotomy between "spontaneous flexibility" and "reactive flexibility", simple and alternate verbal fluency tasks, respectively, were used." "Two forms of cognitive flexibility: (1) **shifting response set (i.e., reactive flexibility)**, and (2) **producing a diversity of ideas (i.e., spontaneous flexibility)."**	Bellaj et al., 2016	

Conceptual definition	Term used	Quotes	Authors	Complete definition
Framework – Higher Order				
Change perspectives/ lifestyles	*Mental Flexibility*	"With increased opportunities for novel and continuing exploration, and the full (and playful) use rather than disuse of our cognitive abilities, decrements in our capacity to creatively and **flexibly grapple** with the world, in ways that do not rely on prior learning or knowledge, may not be as severe, as sharp, or as early as – without such stretching towards mental flexibility – they otherwise would be."	Tranter & Koutstaal, 2008	X
	Adaptability	"Adaptability refers to flexibility toward **changing situations and lifestyles.** Here, emotional shifting leads to flexible planning, developing more alternatives, and widening perspectives."	Alavi et al., 2019	X
	Cognitive flexibility	"Cognitive flexibility is a constituent of executive functions that has a determining role in individuals' behavior. It is the ability to **change perspectives**, think outside the box, and nimbly adjust to altered demands or priorities"	Shoghi Javan & Ghonsooly, 2018	X
	Fluid Intelligence	"*Fluid intelligence* – our ability to creatively and **flexibly grapple with the world** in ways that do not explicitly rely on prior learning or knowledge"	Tranter & Koutstaal, 2008	X
	Psychological inflexibility	"Third is the feature of psychological inflexibility. Merwin et al. (2011) present a model of AN in which psychological inflexibility, defined as **"an inability to behave flexibly in the presence of difficult thoughts, feelings, and bodily sensations"** (p.63), is considered a key motivation behind the rule-driven and rigid behaviours of the AN sufferer."	Startup et al., 2013	
Environmental adaptability	*Response-flexibility*	Rats exposed to such "enriched environments" also have been shown to have **superior problem-solving skills in complex tasks (maze solving) and show an advantage in various tasks requiring response flexibility**, such as learning a reversal of a previously learned visual discrimination (e.g., Krech, Rosenzweig, & Bennett, 1962).	Tranter & Koutstaal, 2008	
	Cognitive Flexibility	"Shifting is strongly related to **cognitive flexibility**, which involves **adjusting one's perspective or behavioral strategy** in response to **changing environmental demands**."	Cotrena et al., 2016	X
Generation of categories	*Flexibility*	Study 1 explored creative generation with the novel uses paradigm (Guilford, 1950) that allows the simultaneous assessment of three distinct but interrelated components of creativity: fluency (i.e., number of ideas generated), **flexibility (i.e., number of different categories generated)**, and overall creativity or novelty of the ideas generated.	(Tadmor, Galinsky & Maddux, 2012	
Cognitive ability enabled by executive function	*Flexible behavior*	"With regard to internal factors, we focused on **executive function, the higher-level cognitive ability that underpins flexible, goal-directed activity** using working memory, attention shifting, and inhibitory control."	Wang et al., 2016	

Note. This table lists the conceptual definitions used for cognitive flexibility across the articles reviewed. The conceptual definitions are paired to the constructs used by the authors.

3.1.4. Disciplinary Contexts

Across all articles, neuropsychology and neuroscience journals were the most common discipline to use the CF construct (*N* = 17; 34.69%). They were the most represented for the vast majority had a non-clinical focus (*N*=15; 88.24%). Articles published in psychology journals were the second most common (*N*=11; 22.44%). Linguistic articles were the third most common discipline (*N*=6; 12.24%). Articles published in cognition journals were the least common (*N*=2). (%) 12 out of the 49 articles were conducted in a clinical setting, while (%) 37 of the 49 articles were conducted in a non-clinical setting. Clinical articles covered topics such as – anorexia nervosa, dementia, autism, pathological gambling, schizophrenia, stroke, mild cognitive impairment, traumatic brain injury, dissociative disorders, attention deficit hyperactivity disorder (ADHD), bipolar disorder, and Alzheimer's disease.

3.2. Measurements

Measures in this review are defined as instruments or tasks quantifying CF. Table 3 is a comprehensive overview of all measures (see Appendix A). In Table 2 all relevant CF measures are coded by task type, and key output metrics, we discovered 36 individual instruments to measure CF and classified them into our three theoretical frameworks. The descriptions of each CF measure is incorporated into Table 32 It summarizes each measure's test type, response type, purpose, and nature. It is important to evaluate each measure's associated operational definition. The operational definition is defined as a means of measuring a construct. In this review, CF is the construct, the theoretical idea that is not directly observable [53].

Table 2

Description of Cognitive Flexibility Measures

Name of Measure	Cognitive (Ability) Measure		Non-Cognitive Measure		Type of Response		Type of Psychological Test	
	Verbal	Performance	Structured	Unstructured	Recognition	Free Response	*cognitive*	*non-cognitive*
3D wisdom scale			*X*			*X*		*Wisdom*
Alternative Uses task		*X*				*X*	*Divergent thinking*	
Arrows Task		*X*				*X*	*Inhibition Control*	
Attentional Network Task (ANT)		*X*				*X*	*Attention & vigilance*	
Berg Card Sorting Task		*X*				*X*	*Executive functioning*	
Brixton Spatial Anticipation Task		*X*				*X*	*Attention & vigilance*	
Colour Trails Test		*X*			*X*		*Psychomotor speed*	
Computerized faces task		*X*			*X*		*Inhibition control*	
Culture Fair Intelligence Test		*X*				*X*	*Intelligence*	
Digit Span Backward (Digit Span-B)		*X*				*X*	*Working Memory*	
Executive Skills Questionnaire			*X*			*X*		*Behavioral*
Figure Ground task		*X*			*X*		*Visual perception*	
Figure matching task		*X*			*X*		*Cognitive control*	
Global-local task		*X*			*X*		*Attention & vigilance*	
Hayling Sentence Completion Test		*X*				*X*	*Processing speed, inhibition control*	
Language switch + Task switch task	*X*	*X*			*X*		*Attention & vigilance*	
Language switch task		*X*			*X*		*Attention & vigilance*	

Name of Measure	Cognitive (Ability) Measure		Non-Cognitive Measure		Type of Response		Type of Psychological Test	
	Verbal	Performance	Structured	Unstructured	Recognition	Free Response	*cognitive:*	*non-cognitive:*
The Lexical Stroop Sort (LSS) picture-word task:		*X*			*X*		*Language*	
MacQuarrie Test for Mechanical Ability		*X*				*X*	*Visuomotor processing*	
Ruff Figural Fluency Test		*X*				*X*	*Language*	
Smiling Faces Task		*X*				*X*	*Cognitive Control*	
Simple and alternate verbal fluency task	*X*					*X*	*Working memory Language*	
Stroop neuropsychological screening test	*X*					*X*	*Inhibition Control*	
Stroop	*X*					*X*	*Inhibition Control*	
Switching verbal fluency test of the district of Seine-Sant-Denis (TFA-93)	*X*					*X*	*Language*	
The Dragon's house		*X*			*X*		*Attention & vigilance*	
TMT-B		*X*				*X*	*Attention & vigilance*	
Tower of Hanoi		*X*				*X*	*Problem Solving*	
Verbal clock test	*X*					*X*	*Neurocognitive*	
Verbal fluency test	*X*					*X*	*Language*	
WCST		*X*				*X*	*Executive Functioning*	

Note. Types of psychological tests are categorized into cognitive and non-cognitive measures. Cognitive: Divergent thinking, Inhibition Control, Attention & vigilance, Executive functioning, Psychomotor speed, Intelligence, Working Memory, Neurocognitive, Visual perception, Cognitive control, Processing speed, Neurocognitive, Language, Visuomotor processing And Problem Solving. Non-cognitive: Wisdom and Behavioural. The cognitive measures were divided into verbal and performance categories and non-cognitive measures were divided into unstructured and structured categories. Measure response types fell into two categories: recognition or free response.

3.2.1 Operational Definitions

Operational definitions are presented in Table 3 and describe how CF conceptual definitions are implemented relative to their measure (see Appendix A). Within this review, we explore 13 operational definitions. The lower-order framework (LO) captures 54% (7), the dichotomous framework (DI) captures 15% (2), and the high-order framework (HO) captures 31% (4) of these operational definitions. Each instrument has an operational definition that determines how the instrument is used and how it measures CF. The operational definitions differed within each theoretical framework.

3.2.2. Description of Measures

Within the LO theoretical framework, the Shape School measure requires children to successfully switch between two different stimuli (i.e., colour vs. shape) and correctly respond [42]. Similarly, the TMT-B asks examinees to alternate between different stimuli, but instead of colours and shapes, the task requires them to connect circles containing either numbers or letters [46]. In the DI theoretical framework, the Wisconsin Card Sorting Task and the Alternative Uses Task are joined together to form a complementary operational definition that includes both reactive and spontaneous flexibility [44, 51]. In the HO theoretical framework, the Alternative Uses Task focuses on the generation of categories, while the Culture Fair Intelligence Test concentrates [1] [2] on noticing relationships, and the TMT A&B, Smiling Face Task (Task Switching Paradigm), and Arrows Task focus on switch costs and inhibitory control. The Culture Fair Intelligence Test is the only measure that considers CF as influencing intelligence [52]. The Computerized Faces Task also stands out because it is the only instrument that measures several executive controls such as response suppression, inhibition control, and switching [13].

3.2.3. Data Extraction

Of the 36 measures, 20% (7) were implemented several times across multiple articles. Usage frequency of each of these measures across our 49 articles varied considerably (2 to 14 times). Frequency of measure usage, in order from most common to least common, were: TMT-B (14), Wisconsin Card Sorting Task (8), Stroop Task (5), Alternative Uses Task (2), Colour Trails Test (2), and the Dimension Change Card Sort (2). The remaining measures, 80% (29) of the total 36 measures, were each implemented in one article. CF measures and operationalizations are used across many contexts; 76% (37) of our 49 articles are conducted in a non-clinical setting.

3.2.4 Cognitive Measures and Questionnaires

Psychological measures are categorized into cognitive tasks and questionnaires (i.e., non-cognitive tasks) (see Table 2). Cognitive measures assess the maximal cognitive or verbal performance of each participant. Cognitive and verbal performance are considered separately in this review. This is

because CF conceptualizations differ between these two instrument types. The cognitive performance tests measure maximal execution of ability on a task without much use of language. Conversely, verbal performance tests require language skills to solve a problem. Questionnaires assess innate traits (i.e., personality, intelligence) where participants do not require specific training. In this review, 94% (34) of the 36 measures are cognitive tests, while 6% (2) are questionnaires (i.e., 3D wisdom scale and the Executive Skills Questionnaire).

Language. Measures with a language component aim to measure the CF of specific linguistic groups. Verbal cognitive measures used to assess CF are the Simple and Alternate Verbal Fluency Task, the Verbal Clock Test, and Verbal Fluency Test. In the LO framework, 10% (3) of the 31 measures focus on an aspect of language. All measures in language-focused articles were from the LO framework and were completely absent from the DI and HO frameworks. In total, 44% (11) of our articles mentioned language in some way. Language measures' implementation and interpretation differed drastically from one another. For instance, Desideri and Bonifacci [21] used the Attentional Network Task (ANT) to measure the influence of bilingualism on executive functioning, while Christoffels and colleagues [16] made use of the Global-local task to assess whether bilingualism promoted task-switching performance and flexible mindsets.

3.2.4. Type of Response

Within the cognitive measures and questionnaires previously mentioned there are two possible response types - free-response and recognition (see Table 1). Free-responses direct participants to recall information and solve questions freely without response constraints (e.g., the Alternative Uses Task). In cognitive science, recognition responses are "multiple-choice questions where one can look for the correct answer among the options, recognize it as correct, and select it as the correct answer" [17] (e.g., Colour Trails Test, the Dragon's House). Roughly 65% (22) of the 34 cognitive measures make use of free-response techniques, while 35% (12) use recognition techniques for collecting participant data. Of our review's 36 measures, there were twice as many free-response (24) versus recognition (12) response types present across cognitive measures and questionnaires.

3.2.4. *Types of Cognitive Tests*

The most common types of psychological tests captured participants' ability for attention and vigilance (9) (see Table 2). These tests require participants to shift their attention from one stimulus to another to test mental switching ability. These measures include the Attentional Network Task, Brixton Spatial Anticipation Task, Global-local task, Intradimensional/Extradimensional Set-shifting task, Language switch + task switch task, Language switch task, Shape School - switch condition, Dragon's House, and the TMT-B. Among these articles, CF is commonly perceived as a type of attention and is

classified as a subcomponent of the LO theoretical framework. The second most common type of cognitive tests are inhibitory control measures. Inhibitory control measures require participants to inhibit their automatic behavioural responses to stimuli. These measures include the Arrows Task, Computerized Faces Task, Hayling Sentence Completion Test, Stroop neuropsychological screening test, and Stroop Task (see Appendix B). For instance, the Arrows Task [55] asks participants to "press the button on the opposite side of where the arrow appeared" when their immediate impulse would be to press the button on the same side as the arrow.

3.2.5. *Measurement Populations*

There are distinct CF measures implemented in specific age groups. Researchers measured CF in all populations more frequently with free-response type measures: young populations under 18 years old (16% of articles), adult populations (52% of articles), and geriatric populations (17% of articles). Free-response measures might be favoured because they allow for valuable inferences to be made from performance.

CF measures are also used in both non-clinical and clinical settings. The vast majority of articles 76% (37) of the 49 articles were conducted in a non-clinical setting. CF measures and operationalizations are used across a wide variety of research contexts. Of the total 37 articles, all (4) of the HO framework, all (2) of the DI framework, and the majority (31) of the LO framework took place in non-clinical settings. For example, the 3D Wisdom Scale, Wisconsin Card Sorting Task, Alternative Uses Task, and Culture Fair Intelligence Test were measures that took place across the 3 theoretical frameworks in non-clinical settings. And 25% (12) out of the 49 articles were conducted in a clinical setting. Clinical articles cover topics such as anorexia nervosa, dementia, and Alzheimer's disease and utilize measures such as the Brixton Spatial Anticipation Task, Trail Making Task, and Stroop Task. This finding suggests that CF is considered a highly valuable concept applicable to a wide variety of research contexts. The fact that CF is of importance for various mental health illnesses, as well as neurological diseases, ran counter to our expectations. We hypothesized that CF would be mainly used in an exploratory and theoretical manner rather than as a diagnostic tool. In cultural and non-cultural contexts, the definitions used for CF spanned all three theoretical frameworks equally. Furthermore, there was no unique pattern in measurement choice amongst cultural articles compared to other research articles.

4. Discussion

This article aimed to evaluate the various CF conceptual, operational, and methodological practices present across disciplines. We did this by selecting 49 studies in a systematic literature review and categorizing their CF definitions and measures into three distinct theoretical frameworks. Subcategories were used to distinguish the differences both between and within each theoretical framework. First, we hypothesized that neuroscience disciplines would have the most well-developed CF definitions and measures. Our results partially supported this hypothesis; however, due to a small number of CF definitions being provided, our results did not point to any conclusive findings. Second, we hypothesized that all three theoretical frameworks would have their own unique and homogenous set of CF definitions. However, this was not the case; only the LO framework has homogeneous CF conceptualizations while the HO framework is diverse. Across all three frameworks, we analyzed which types of measures were most frequently used to operationalize CF. Results indicate that each framework makes distinctive choices about the measures they utilize; most notably the HO theoretical framework uses many LO measures. Our study's results show that even though there have already been decades of research invested into the CF construct, the CF field lacks conceptual coherence in its theoretical and methodological approach. As such we propose a new theoretical framework for studying CF, the basis of which lies in viewing CF as a *meta-competency.* This theoretical framework suggests a standardized terminology and methodological approach for CF research. This theoretical framework hopes to remove the obstacles that have hindered researchers' advancements in CF.

4.1. Principal Findings

4.1.1. Lack of Conceptual Definitions

There was a lack of CF definitions in the review. Most studies reviewed gave no conceptual definition of CF (60%). Of those who did, 25% of studies provided a complete definition; while 35% of studies gave partial definitions. Researchers who do define CF in their articles, leave readers with the challenge of incorporating one conceptualization into a sprawling network of other diverse CF definitions. This may hinder researchers in different disciplines from comparing CF study findings and integrating their knowledge into a cohesive framework. Finding so few complete definitions ran counter to our expectations. This may be the result of authors assuming everyone, both within and outside of their discipline, shares a common conceptualization of CF and that therefore explicitly stating definitions, is unnecessary. Another reason for the low quantity of definitions may be that many researchers use their measurement tools as a proxy for a definition.

4.1.2. Different Definitions and Measures Across Frameworks

Different definitions and measures of CF exist across frameworks. Each discipline emphasizes different elements of CF (i.e., LO or HO). Researchers in each framework seem to isolate the CF components (e.g., switching, attention, creativity) most pertinent to their discipline. For instance, biological disciplines, such as the medical sciences, define CF as solely on lower-order elements (i.e., attention). In contrast, psychological disciplines, such as psychotherapy, consider higher-order elements of CF (i.e., creativity) as CF. In line with our hypothesis, each discipline appears to have different traditions for studying CF. Researchers often present a single aspect of CF as the only relevant CF concept, leading readers to conclude that each article's CF focus is the true definition of CF.

4.1.3. Lower-Order Framework

There are more definitions and measures within the LO theoretical framework than in any other theoretical framework (HO or DI). The definitions (i.e., conceptualizations and operational definitions) and measures are more uniform in the LO framework. As a result, articles from this framework are clearer and more consistent in their measures. This uniformity exists because all authors agree that CF is a component of executive function that enables cognitive shifts from one cognitive object to another. Differences between definitions originate from nuances surrounding the nature of the cognitive objects involved in the cognitive shift.

4.1.4. Higher-Order Framework

In comparison, the HO theoretical framework showed little agreement on CF conceptualizations and operationalizations beyond CF being an overarching feature of a cognitive system. CF definitions in the HO framework are often vague, if present at all, and lack specificity about the mental processes involved in CF. Common definitions of CF in the HO framework were: changing perspectives/lifestyles, environmental adaptability, and generation of categories. Definitions in this framework are open-ended and therefore easier for researchers to adopt and apply to their studies. However, beyond CF being an overarching feature of a cognitive system, there is little agreement on CF conceptualizations and operationalizations. The LO framework had more complete conceptual definitions present ($N = 18$) than the HO framework ($N = 6$).

4.1.5. Dichotomous Framework

The DI framework is the most proficient out of the three theoretical frameworks at implementing holistic definitions and measures of CF. While not employed as often as LO, the DI theoretical framework integrates both the LO and the HO frameworks by defining each in relation to one another. As such, measures for both lower-order and higher-order CF exist under this framework. The two CF constructs under the DI dichotomous framework are *reactive* and *spontaneous flexibility.* The conceptual definitions were closely matched to their operational definitions. In the DI framework, each

article used two measures in a complementary fashion, where the measure outputs were used to inform one another. For example, the Wisconsin Card Sorting Task is a measure of *reactive flexibility* and the Alternative Uses Task is a measure of *spontaneous flexibility*. The two measures were combined in the DI framework to form a holistic operational definition that is more faithful and realistic to conceptions of CF than the other frameworks. This shows that in the DI framework there is alignment between researchers' conceptual definition and operationalization. This increases theoretical coherence in the researcher's work in the disciplines associated with DI.

4.2. Secondary Findings

4.2.1. Attentional Measures

The only consensus in CF measures exists in the LO framework articles, as attention measures. This choice in measures shows that disciplines associated with the LO framework are united in their view of CF as an attention and vigilance capacity. Additionally, inhibition control measures (e.g., Arrows Task, Computerized faces task, and Stroop Task) were the second most common type of psychological test. The popularity of these measures indicates how disciplines in the LO framework have a certain degree of agreement that CF involves inhibition processes. The other two frameworks, HO and DI, lack a consensus in measurement type across articles; therefore, our review cannot conclude the dominant view of CF in its associated disciplines. This is in agreement with our hypothesis that currently, the majority of researchers perceive CF's most critical attribute to be its implication in attention. This dominance of attentional measures may contribute to the widespread conception that CF is synonymous with attention and inhibitory control.

4.2.3. Measure Adaptability Across Populations

Specific CF measures are implemented in specific population age groups. Our finding shows that CF measurement selection can be adjusted to the study's population age group and mental faculties (i.e., cognitive deficits). Researchers more commonly measure CF in adult populations with free-response type measures (52% of articles). Approximately 31% (15) of the 49 articles focused on measuring CF in younger populations (under 18 years old) and most frequently used free-response type responses (16% of articles). In geriatric populations, free-response types of measures are used most frequently (17% of articles). Free-response measure types may be preferred because they allow for deeper extrapolations to be made from performance as they require a greater level of cognitive involvement from participants. Although recognition techniques involve fewer cognitive faculties, in clinical and developmental studies where participants have diminished or developing cognitive capacities, it allows for testing to take place. For example, the Stroop Task is used for geriatric populations, the Wisconsin Card Sorting Task in schizophrenic adults, and the Berg Card Sorting Task

used for children with autism. This flexibility in measurement's response types may allow researchers to minimize measurement errors in different populations. This finding is in line with our expectation that CF measures could be used across age groups. However, we were unaware that CF measures could be chosen with consideration of a population's different mental capacities. This allows CF measures to be used across a wide variety of research contexts and disciplines.

4.3. Strengths

Though this systematic literature review is not the sole publication on the CF concept and its fragmented theoretical underpinnings, ours is, to our knowledge, the first review to catalogue the conceptual and operational definitions of CF across various disciplinary contexts.

4.4. Limitations

4.4.1. Sample Size

Since most articles only address CF peripherally, our review's sample size ($N = 49$) provided small amounts of information from which to draw definitive conclusions about how researchers conceptualize CF. The lack of CF conceptual definitions in each research article also impacted the depth of our CF measures analysis because it stopped us from determining whether the researcher's corresponding measurement choice in the research article was appropriate. This reduced our ability to determine the validity and strength of the relationship between theory and psychometric study design within different CF research disciplines.

4.4.2. Article Bias

Biases may exist in the selection of our research papers due to two limitations in our search strategy. First, we were biased towards using articles that provided a lot of information; therefore, we might have missed fields where CF is frequently used, in a less apparent way. This contrasts with fields in which CF is used less frequently but more noticeable. Second, because we emphasize articles that address CF in detail, these paper's CF perspectives may have dominated our review's findings. In our review, more articles from the neuropsychology field provided CF information and therefore may have biased our review's conclusions.

4.4.3. Terminology

Across all three theoretical frameworks, *cognitive flexibility* was the most prevalent term used to refer to the CF concept. It was used in association with a total of 19 (out of 36) measures. For example, both the executive functioning ability *to shift attention* and the creative ability to *generate multiple categories* are both referred to as *cognitive flexibility.* As a result, the over-use of this one term, *cognitive flexibility* to refer to so many different conceptualizations of CF had counterproductive effects

for our review. This is because it made it challenging for our review to distinguish between researchers CF definitions and consequently difficult to determine each discipline's understanding of CF.

4.4.4. Measure Analysis

Our review only provides a descriptive account of measures and aims to speak to researchers' measure choice and frequency of usage. We did not evaluate the quality of the measures (i.e., psychometric analysis), therefore our review cannot provide commentary on this subject.

4.4.5. Cultural Measures

Although our study aimed to describe the definition and measure of CF used in research with a cultural focus, we were not able to provide commentary on the subject. This is because we found no noticeable difference between the definitions and measures for CF in cultural versus non-cultural research.

4.4.6. Future Directions

Considering these limitations, future research may require a larger sample of articles and use medical databases to capture articles with a more clinical focus. Furthermore, as the field is still emerging, it would be beneficial for a future study to analyze CF in research more generally rather than limiting article selection through conceptual and psychometric criteria.

4.5. Implications

4.5.1. New Cognitive Flexibility Conceptualizations

From the findings of our review, it is evident the CF field's current inconsistent theoretical and measurement practices are hindering advancements in the field. The need for CF research to be united under a single theoretical framework is clear. Of the three theoretical frameworks outlined in our article, we believe the DI framework's definition is the most beneficial. To guide future research, our review recommends a new CF definition (based on the DI framework) we call "CF meta-competency". This definition considers CF to be a cognitive system's general ability to be flexible. We believe this overarching CF capacity is underpinned by the operation of many systems at both lower (i.e., processing speed, attention, memory) and higher-order levels (i.e., creativity). Our definition simultaneously accepts low and high-level CF as *key competencies* of CF, yet recognizes that alone, neither of these capacities is CF itself. As a result, our definition of CF delineates the conceptual and operational definitions that are appropriate and necessary to count as CF. Consequently, our meta-competency definition may provide the necessary structure to allow researchers from diverse disciplines to organize extant knowledge into a single, clear theoretical framework. We hope that our integrative meta-competency paradigm may unite researchers across many disciplines.

4.5.2. Increased Specificity in Cognitive Flexibility Terminology

Researchers' current lack of specificity in CF terminology would benefit from a common taxonomy. Our meta-competency framework could help facilitate the implementation of a uniform taxonomy that allows for clear theoretical distinctions between and across different CF constructs. We propose that in higher-order conditions when referring to more global, complex brain functions of CF such as creativity, category-generation, and social adaptability, the term *cognitive flexibility* should be used. For lower-level functions related to executive functioning (i.e. processing speed, attention, and memory), we believe the term *cognitive flexibility* is inappropriate. Instead, researchers should use terminology specific to the low-level processes of CF they are examining. For instance, when using a *task-switching* measure and researching CF's related attentional switching capabilities, the term *flexible attentional control* may be used. By using terminology that is operationally referenced, conceptual definitions can line up with operational definitions and therefore increase clarity. Furthermore, by refining which CF constructs each conceptual definition is allowed to be paired with, referencing consistency may be increased when referring to a specific phenomenon. It is clear that if the field is going to progress, the construct CF can no longer be used haphazardly as a blanket statement to refer to all conceptualizations across all disciplines; boundaries must be established. Subsequently, authors may more accurately reference each other's work and make more insightful comparisons across findings. This would allow researchers to provide commentary and hold meaningful intellectual discussions more efficiently.

4.5.3. Measurement

First, we suggest CF researchers should create clarity on which measures are effective at assessing CF meta-capacity. More higher-order cognitive measures need to be verified as appropriate for CF research. This could be established by cross-validating higher and lower order CF measures to see which outcomes are related. For instance, measure outcomes could be compared between the AUT, WCST, and TMT-B. If there is no convergence between these higher and lower order measures, then they are not measuring the same thing (i.e., CF). Second, due to CF's multifaceted nature, "it is unlikely to be well measured by any single task" (Yu, et al., 2019). Therefore, we recommend future CF research studies be designed to use a combination of different tasks to capture the CF meta-competency. This may help "to more closely mirror the challenging experience of naturalistic problem solving outside of the laboratory setting" (Yu, et al., 2019). Third, a standardized way of extrapolating CF capacity from measure performance could be established. For instance, each measure could be linked to a specific element of the theoretical framework. For example, the TMT-B measures assess task switching capacity, but not CF in general.

4.6. Conclusion

4.6.1. Findings

Across the three frameworks, the main differences amongst the measures and definitions of CF are: (1) the mechanisms and functions believed to be enabled by CF, (2) the degree of homogeneity between conceptual and operational definition, (3) the level at which CF is discussed (i.e., lower or higher). Overall, our review found few articles that provided clear definitions of CF. By analyzing the extent CF definitions across our three theoretical frameworks, we were able to determine that the LO framework and its associated disciplines had the most complete CF definitions. Furthermore, the most common CF measures were based on attentional control and belonged to the LO framework. These biologically based measures were commonly used in the other two theoretical frameworks. As a result, both LO definitions and measures seemed to dominate researchers' conceptualizations of CF regardless of discipline. Furthermore, the CF definitions present in the HO framework had greater diversity than the CF definitions present in the LO framework. This illustrates that there is greater consensus in more biologically based disciplines as to CF's definition compared to more theoretical disciplines (e.g., psychology etc.). In general, the dichotomous framework had CF definitions that we deemed the most constructive for research because they were holistic, that is, they incorporated both higher and lower order definitions of CF. We found a high degree of adaptability in CF measures in terms of the way they could be adjusted to be used in specific population groups and various levels of ability. Overall, it seems that the disciplines associated with the LO frameworks and conceptualizations of CF are far more developed.

4.6.2. Implications

Inconsistent definitions, terms, and measures for CF make it challenging for CF researchers to distinguish between CF conceptualizations and compare research findings. This ambiguity delays advancements in the CF field. Furthermore, we suspect that for researchers outside of the field, the barrier to understanding the basic theoretical and methodological notions surrounding CF is so high that curiosity is quickly halted. We proposed the unified framework of meta-competency to unify research efforts and increase clarity within the CF research field. Our meta-competency frameworks delineate a clear taxonomy for CF and suggest the use of consistent CF definitions and measures. This simultaneous acceptance of LO and HO definitions of CF may help balance the lower-order bias in CF research. It may also clarify the role of both lower and higher-order CF elements in CF capacity. Through this clearer framework, the CF field has the potential to develop at a much faster rate and take its rightful place as a key cognitive mechanism across neuroscience and psychology disciplines.

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6. Appendix

6.1. Appendix A

Table 3

Comparison of Operational and Conceptual Definitions

Name of Measure	Term(s) used	Operational definition	Conceptual Definition	Author(s)	Context
Executive Functioning					
Hayling Sentence Completion Test	*Cognitive flexibility*	The difference between the time taken to complete both parts of the task (Hayling Test Part B speed – Hayling Test Part A speed) and the ratio between these two values (Hayling Test Part B speed/Hayling Test Part A speed) provide measures of cognitive flexibility and switching.	Adjustment of behavioral strategy	Cotrena et al., 2016	Non-Cultural
Ruff Figural Fluency Test	*Switching*	Examinees are asked to produce novel designs through connecting dots with specific configurations within a minute.	Ability to switch/shift between mental sets	Ross et al., 2017	Non-cultural
Shape school – switch condition	*Switching*	Correct responding in this condition requires a child to be able to switch successfully between the two different responses (i.e., color vs. shape).	Ability to switch/shift between mental sets	Rato et al., 2018	Culture-normed
The Dragon's house	*Flexibility*	Ability to switch attention between two kinds of information sources.	Attending different stimuli/attention	Sobeh & Spijkers, 2012	Non-cultural
TMT-B	*Cognitive flexibility*	Examinees are asked to rapidly connect circles containing numbers and letters in ascending order, while alternating between connecting numbers and letters.	Ability to switch/shift between mental sets	Seçer, 2016	Culture-normed
WCST	*Cognitive flexibility*	Examinees are asked to sort a stack of cards according to specific card attributes and to adjust their sorting strategy in response to feedback. Note, both in-person and computerized administrations of this test have been used.	Ability to switch/shift between mental sets	Ross & Melinger, 2017	Non-cultural
Brixton Spatial Anticipation Task description	*Psychological inflexibility*	The Brixton Spatial Anticipation task is computerized and requires participants to predict movement patterns of a specific stimuli and adjust their expectations based on changes they notice.	Adjustment of behavioral strategy	Startup et al., 2013	Non-cultural
Dichotomous					
WCST (reactive) + AUT (spontaneous)	*Spontaneous and reactive flexibility*	Reactive: WCST preservation errors // Spontaneous: AUT generation of categories	Two distinct forms of flexibility	Dahlman et al., 2013	Specific culture
Simple and alternate verbal fluency task	(Eslinger and Grattan, 1993)	"We examined verbal fluency via three conditions: a simple semantic word fluency task using the category "Animals", a simple phonemic word fluency task using the letter "M", and an alternating word fluency task in which the child was invited to alternate between phonemic and semantic criteria: "Clothing" and the letter H" *spontaneous: semantic word fluency + reactive: task switching]*	Two distinct forms of flexibility	Bellaj et al., 2016	Specific culture

Name of Measure	Term(s) used	Operational definition	Conceptual Definition	Author(s)	Context
Higher order					
Alternative Uses task	*Flexibility*	AUT generation of categories	Generation of categories	Tadmor, Galinsky & Maddux, 2012	Culture-normed
Culture Fair Intelligence Test	*Fluid intelligence*	"The tests used are non-verbal and require participants to attempt to perceive relationships between shapes and figures."	Change perspectives/lifestyles	Tranter & Koutstaal, 2008	Culture-normed
TMT A&B; Smiling Face Task (Task Switching Paradigm); Arrows Task	*Flexible behavior*	Switch costs and inhibitory control were measured as part of executive function measures. Cognitive flexibility is measured directly using switch costs but is not given a conceptual definition at the executive function level.	Cognitive ability enabled by executive function	Wang et al., 2016	Culture-normed
Executive Skills Questionnaire	*Flexibility*	The Questionnaire contains 36 questions based on a 7-point Likert scale. The questions are grouped into 12 categories that measure different executive function skills.	Change perspectives/ lifestyles	Alavi et al., 2019	Culture-normed

Note. This table lists the operational definitions for which a corresponding conceptual definition could be identified. Therefore, this is not a comprehensive list of operational definitions and of measures.

Appendix B

Table 4

Operational Definitions of Cognitive Flexibility Constructs in Cultural Contexts

Theoretical Framework		**Lower Order**			
Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context
3D wisdom scale	Cognitive flexibility	The 3D wisdom scale is a self-rated questionnaire that assesses wisdom. It includes 39 items across three dimensions and correlates higher scores with greater wisdom.	N/A	Kim & Knight, 2015	Culture-normed
Arrows Task	Flexible behavior	This instrument measures inhibition control by asking participants to indicate the direction opposite to where each arrow was pointing.	Cognitive ability enabled by executive function	Wang et al., 2015	Culture-normed
Attentional Network Task (ANT)	Cognitive Flexibility	Measures the cognitive cost of an incongruent stimuli requiring conflict resolution in comparison to a congruent stimulus being presented. The stimulus in question is an arrow surrounded by other arrows either pointing in the same direction (congruent condition) or in a different direction (incongruent condition). The participant must indicate the direction of the central arrow only.	N/A	Desideri & Bonifacci, 2018	Language
Berg Card Sorting Task	Cognitive Flexibility	Computerized implementation of the Wisconsin Card Sorting Task. See note on WCST.	N/A	Shu et al. 2001	Culture-normed
BRIEF	Cognitive Flexibility	BRIEF (Behavior Rating Inventory of Executive Function) is an 86-item questionnaire developed for school-age children to assess executive function at home and at school.	N/A	Fernández et al., 2014	Culture-normed
Brixton Spatial Anticipation Task	Psychological Inflexibility	The Brixton Spatial Anticipation task is computerized and requires participants to predict movement patterns of a specific stimuli and adjust their expectations based on changes they notice.	Adjustment of behavioral strategy	Startup et al., 2012	Non-cultural
Colour Trails Test	Cognitive Flexibility	Examinees are asked to rapidly connect circles containing numbers in ascending order, while alternating between two circle colours.	N/A	LaRue et al., 1999; Avila et al., 2019	Culture specific

Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context
Computerized faces task	Cognitive Flexibility	This is a test that assesses three executive controls: response suppression, inhibition control, and switching. Participants were shown a schematic face whose eyes change gaze direction and color. The goal was for participants to indicate the eye color while facing a visual distraction (an asterix) on the screen.	N/A	Bialystok & Viswanathan, 2009	Culture specific
Digit Span Backward (Digit Span-B)	Mental manipulation/ cognitive flexibility	The Backward task requires the individual to repeat numbers in the reverse order of that presented. (Coalson et al., 2010)	N/A	Mendoza et al., 2020	Culture specific
Dimension Change Card Sort (DCCS)	Cognitive flexibility / set shifting	Examinees are required to sort stimuli according to an explicitly stated rule, and the rule changes as the task progresses.	N/A	Moriguchi et al., 2010; Flores et al., 2017	Culture-normed
Figure Ground task	Cognitive flexibility	The Figure Ground task measures visual perception and impulse inhibition. It involves separating different stimuli by identifying the figure in the foreground from the background of the image.	N/A	Dahlman et al., 2013	Culture specific
Figure matching task	Cognitive flexibility	In the Figure matching task, a test of cognitive control, each trial presented a different target stimulus and asked the participants to indicate if the new stimulus matched the target.	N/A	Ellefson et al., 2017	Culture specific
Global-local task	Cognitive flexibility	The Global-local task, a test of focused attention, presents global stimuli (large shapes) and local stimuli which are smaller shapes that make up the larger ones. The participants were asked to determine which local stimuli made up the global stimuli.	N/A	Christoffels et al., 2014	Language
Hayling Sentence Completion Test	Cognitive flexibility	Examinees are asked to complete a series of sentences with missing last words either naturally or by producing an irrelevant word.	Adjustment of behavioral strategy	Cotrena et al., 2016	Non-Cultural

Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context
Intradimensional/ extradimensional set-shifting task	Extradimensional (ED) Shifting	Examinees are required to make a series of discriminations based on intra-stimulus attributes and external stimuli cues with computerized feedback; discrimination rules change over the task.	N/A	Grant et al., 2012	Non-Cultural
Language switch task	Mental Flexibility	This is a test of executive control over multiple languages. Words from two different languages were presented to bilingual participants. Their response time was measured between the presentation of the word and the identification of the language.	N/A	Aparicio et al., 2017	Language
The Lexical Stroop Sort (LSS) picture-word task	Cognitive Flexibility	This computerized task measures executive function and its correlation to language development.	N/A	Parramore & Wilbourn et al., 2011	Culture-normed
MacQuarrie Test for Mechanical Ability	Set-Switching	The t-MQTMA assesses visuomotor processing speed by measuring hand–eye coordination and muscular control. Participants must draw three dots in as many circles possible in 30 seconds. The total number of dots was calculated as a score.	N/A	Llinàs-Reglà et al., 2017	Culture-normed
Ruff Figural Fluency Test	Switching	Examinees are asked to produce novel designs through connecting dots with specific configurations within a minute.	Ability to switch/shift between mental sets	Ross et al., 2007	Non-cultural
Shape school - switch condition	Switching	It tells the story of students who are illustrated as shapes. In the switch condition, children are told that some shapes are wearing hats and have changed names. The child's goal is to successfully switch between naming the shapes with and without hats.	Ability to switch/shift between mental sets	Rato et al., 2018	Culture-normed
Smiling Faces Task	Flexible Behavior	Participants in this task are asked to identify the emotion and gender of each face presented on screen to measure cognitive flexibility.	Cognitive ability enabled by executive function	Wang et al., 2015	Culture-normed
Stroop neuropsychological screening test	Switching	A simplified Stroop test with two conditions; naming colour patches and naming the ink colour of highly interfering text.	Ability to switch/shift between mental sets	Ross et al., 2007	Non-cultural
Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context

Stroop	Cognitive flexibility Mental flexibility Set-shifting	Examinees are asked to name the colour of ink patches or texts; some texts are colour names printed in incongruent ink colours to create cognitive interference. In the switching condition of this task, examinees are asked to alternate between word-reading and colour reading in a single trial.	N/A	Anderson et al., 2017; Bialystok et al., 2014; Libon et al., 2007; Llinàs-Reglà et al., 2017; Rognoni et al., 2013	Culture-normed
Switching verbal fluency test of the district of Seine-Sant-Denis (TFA-93)	Cognitive flexibility	(Administered in French) Examinees are asked to produce names of animals and names of fruits, respectively, in one minute. They are then asked to produce both animal and fruit names while alternating between the two categories.	N/A	Narme et al., 2019	Culture specific
Symbol Digit Test	Mental flexibility	Examinees are asked to rapidly write down numbers corresponding to a series of symbols using a key of paired symbols and numbers.	N/A	Constantinidou et al., 2012	Culture specific
The Dragon's house	Flexibility	A computerized task that measures attentional shifting in children. The child is instructed that one computer key is assigned to the green dragon and another to the blue dragon. The child must accurately press the key associated with the specific dragon as it appears on screen.	Attending different stimuli/ attention	Sobeh & Spijkers, 2012	Non-cultural
TMT-B	Cognitive flexibility	Examinees are asked to rapidly connect circles containing numbers and letters in ascending order, while alternating between connecting numbers and letters.	Ability to switch/shift between mental sets	Anderson et al., 2017; Libon et al., 2007; Kim et al., 2017; Bialystok et al., 2014; Adjorlolo, 2016; Dias et al., 2013; Ihle et al., 2016; Fernández & Marcopulos, 2008; Llinàs-Reglà et al., 2017; Avali et al., 2019; Ross et al., 2007; Seçer, 2016; Constantinidou et al., 2012; Wang et al.,2015	Culture-normed
Tower of Hanoi	Switching	The Tower of Hanoi is a test of problem-solving ability using rods and different sized plates. The goal is to place all plates on one rod in order of smallest (top) to largest (bottom) with respect to specified rules.	Ability to switch/shift between mental sets	Ross et al., 2007	Non-cultural

Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context

Verbal clock test	Cognitive Flexibility	Examinees are asked a series of questions about components of a standard clock-face, placement of clock hands for a specific time, and reading time given verbal descriptions of clock hand positions.	N/A	Cercy, 2012	Non-cultural
Verbal Fluency Test	Mental Flexibility Cognitive Shift Cognitive Flexibility	Examinees are asked to produce words based on a phonemic criterion (e.g., starting with letter F) within a minute. They are asked to produce words based on a semantic criterion (e.g., animals) in another condition.	N/A	Llinàs-Reglà et al., 2017; Constantinidou et al., 2012	Culture specific
WCST	Cognitive Flexibility	Examinees are asked to sort a stack of cards according to specific card attributes and to adjust their sorting strategy in response to feedback. Note. Both in-person and computerized (BCST) administrations of this test have been used.	Ability to switch/shift between mental sets	Harvey et al., 2001; Kim et al., 2017; Shu et al., 2001; Javan & Ghonsooly, 2017; Liu et al., 2011; Avali et al., 2019; Ross & Melinger, 2017, Ross et al., 2007	Culture specific
Theoretical Framework		**Dichotomous**			
WCST (reactive) + **AUT** (spontaneous)	Spontaneous and reactive flexibility	WCST: WCST measures the executive, coordinative function needed to develop and maintain a problem-solving strategy when stimulus conditions are changed. AUT: The AUT was developed by Guilford in 1971 as a divergent task in which the goal is to generate as many uses as possible for familiar objects.	Two distinct forms of flexibility	Dahlman et al. 2013	Culture specific
Simple and alternate verbal fluency task	(Eslinger and Grattan, 1993)	Children are asked to generate words according to a phonemic criterion (e.g., the letter H) and a semantic criterion (e.g, animals) respectively, and then to produce words alternating between a new phonemic and a new semantic criterion.	Two distinct forms of flexibility	Bellaj et al., 2016	Culture specific

Name of Measure Used	Term(s) used	Measure Description	Conceptual Definition	Author(s)	Context
Theoretical Framework		**Higher Order**			

Alternative Uses task	Flexibility	The Alternative Uses task asks participants to imagine all the possible uses for a given object under time a constraint. This test measures divergent thinking and categorizes the responses by originality, fluency, flexibility, and elaboration.	Generation of categories	Dahlman et al., 2013; Maddux et al., 2012	Culture-normed
Culture Fair Intelligence Test	Fluid intelligence	This instrument measures intelligence by asking participants to find a relationship between shapes and figures in a way that reduces the influence of verbal fluency, cultural climate and educational level.	Change perspectives/lifestyles	Tranter & Koutstaal, 2008	Culture-normed
Executive Skills Questionnaire	Flexibility	The Questionnaire contains 36 questions based on a 7-point Likert scale. The questions are grouped into 12 categories that measure different executive function skills.	Change perspectives/lifestyles	Alavi et al., 2019	Culture-normed

Note. Measures were paired with constructs, operational definitions, and conceptual definitions. The purpose of this table is to illustrate how authors' theoretical understanding of CF is manifested in their instrumental practice. Author and publication year is listed next to each measure. In instances where multiple authors used these same measures and conceptual definition pairing, the relevant authors were then listed within the same row. All the measures, based on their conceptual definitions, were paired into three theoretical frameworks (EF, DI, HO). Measures were also sorted into three categories (culture-normed, culture specific, and non-cultural) based on the cultural context the research took place in and therefore, the measure was used in. N/A signifies that no conceptual definition was used with a measure by a specified author.

III Chapter: Transition

Our work in systematic review allowed us to establish the theoretical *meta-competency* framework which we used to inform the analysis of our findings on the empirical study. Furthermore, having found a paucity of research on CF in cultural contests in our systematic review, we realized the importance of our empirical study to investigate the link between CF and multicultural exposure. The systematic review also grounded our knowledge of the measures bilingualism researchers typically use to support their argument that bilingualism strengthens CF.

IV Chapter: Manuscript 2

The Relationship between Exposure to Multicultural Environments and Cognitive Flexibility

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Author contributions. PB designed the study, created the demographics survey, coded the survey, collected the data, cleaned the data, performed statistical analysis on the data, wrote the introduction, wrote the methods, wrote the results and wrote the discussion. MW assisted with the study design, survey coding, ethics application, data collection, analysis of the Alternative Uses Task, coding the Task Switching Paradigm Test, analyzing data, and provided feedback on the literature review as well as support on the introduction and discussion. TD assisted in the results section, and together both PB and TD coded the tasks switching paradigm measure and performed statistical analysis on the entire dataset. SV and KL supervised PB and offered feedback on the study design and manuscript draft. AR provided guidance on the study narrative and feedback on the manuscript.

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Abstract

Introduction. *Cognitive flexibility,* the ability to adapt to situations in creative ways and shift attention between responses or perspectives, is a field of growing importance in a world where globalization and multiculturalism dominate. The resilience CF confers is of relevance to the domains of development, cognition, and the medical sciences. Though CF has been hypothesized to be enhanced by language switching, results are inconclusive and currently multi-cultural exposure shows the most promise as an explanatory mechanism. Research Question. We aimed to assess the relationship between exposure to multiple cultural environments and CF capacity. Hypothesis. We hypothesize that multicultural experiences will positively predict higher cognitive flexibility.

Methods. Study Design. We compared CF capacity performance between a multicultural and a monocultural participant group across three higher and lower order CF measures: the Task Switching Paradigm Test, the Alternative Uses Task, and Divergent Association Task. Lower-order CF refers to more simplistic, brain-based functions related to executive functioning while higher-order CF refers to more global, complex, brain functions. A sociocultural demographics survey categorized participants as Multicultural's, those who lived in at least three different cultural environments and monocultural's, those who have only lived in one cultural environment. We viewed this study from the theoretical framework of inconsistency resolution which suggests reconciliation between conflicting cultural viewpoints may confercognitive flexibility advantages. Sample. Our sample was psychology undergraduates ($N = 111$); ($n = 51$) monocultural and ($n = 60$) multiculturals.

Results. Data analysis with independent sampled t-test showed trends of multicultural scoring higher than monoculturals on all three higher and lower order CF measures. However, only multicultural performance on a component of the TSPT was significantly different. Namely the letter sub-score, which tests attentional control with letter stimuli.

Conclusion. Future studies are needed to confirm the pattern of findings with a larger sample size. Furthermore, the environments from which participants are recruited need to be more controlled to ensure true multicultural and monocultural exposure. Overall, our study shows multicultural backgrounds may play a role in CF capacity. In particular, our study highlights the potential of the inconsistency resolution framework to be an explanatory model for CF strengthening.

1. Introduction

Cognitive flexibility (CF) is the capacity to simultaneously consider several conflicting representations of an event and create multiple solution procedures (Jacques & Zelazo, 2005 as seen in Ionescu, 2011) - a skill vital for navigating multiple cultural environments. CF allows individuals to adapt to situations in creative ways and shift attention between responses or perspectives (Perone, Almy & Zelazo, 2018; Alavi et al., 2019; Shoghi Javan & Ghonsooly, 2018; Tranter & Koutstaal, 2008) and thus is the cognitive control mechanism thought to underly human's ability to adapt to different contexts (Pringle, 2014). CF is a topic prized by many research disciplines because it facilitates resilience (Buttlemann & Karback, 2017) (i.e., humans' capacity to cope with unexpected situations, and challenging, dynamic environments (Selye, 1976)). CF capacity positively correlates with psychological well-being (Kashdan & Rottenberg, 2010), while impairments in CF can lead to behavioral rigidity that negatively affect daily functioning (Soltani et al., 2013). Variability in cognitive capacity is often theorized by psychologists to be the result of both genetic and environmental factors (Tucker-Drob et al., 2013). CF specifically is believed to be shaped through a reciprocal process between an individual, the environment, society, and biological potentiality (Arieti, 1976; Bourdieu, 1977; Glăveanu, 2010; Hennessey & Amabile, 2010 as cited in Catharine & Marte, 2015). Research has shown deep experiences with two cultures to allow individuals to express greater CF, and therefore better adopt and adapt to the challenges of living in multicultural contexts (Chen & Padilla, 2019). Studies found biculturalism to correlate with superior performance on several different measures of CF including task-switching and creativity paradigms (Christmas & Barker, 2014; Spiegler & Leyendecker, 2017). Yet despite globalization increasing, the effect of navigating multicultural environments on the development of CF remains a relatively under-investigated subject (Tadmore & Tetlock, 2009). Little experimental or empirical evidence exists to support the theorization of a CF advantage in multicultural individuals (Maddux & Galinsky, 2009).

1.1. Terminology

1.1.1. Cognitive Flexibility

Much of the CF research literature fails to provide definitions for CF (Ionescu, 2012). Our current study accounts for this by using a novel framework for CF, called *meta-competency.* The *meta-competency* framework views CF as existing at, and depending on, both *higher* and *lower order* cognitive levels (Bockelmann et al., 2021). *Lower-order CF* refers to more simplistic, executive

functioning skills, predominantly the ability to shift between two or more cognitive sets (i.e., attentional control) (Miyake et al., 2000; Ross et al., 2007). *Lower order CF* is often referred to in literature as task-switching, or mental shifting. *Higher-order CF* is the product of more global, complex, brain functions and is understood as the capacity to adapt to situations in creative ways (Alavi et al., 2019; Shoghi Javan & Ghonsooly, 2018; Tranter & Koutstaal, 2008). *Higher order CF* is also often referred to as divergent thinking, fluid intelligence, and creativity. Employing this *metacompetency* framework allows us to increase our study's conceptual clarity, and demarcate which literature is of relevance to our research.

1.1.2. Multicultural

Multicultural refers to the degree to which someone has knowledge of, identification with, and internalization of more than one societal culture (Vora et al., 2019). Culture refers to the learned associative network of ideas, values, and beliefs that effect individuals' interpretative frames for emotions, cognition, and behavior (Benet-Martinez et al., 2002). Consequently, culture also refers to the way humans' interpret their social environments, coordinate their thoughts and behaviors (Legare et al., 2018), and as a result, how they connect and experience the world (Markus & Kitayama, 2010). Culture also refers to a sense of group membership which provides individuals with a sense of security and safety (Chao et al., 2015). It is therefore unsurprising the social and cultural contexts in which humans are raised shape their cognitions, expectations, and neural patterns (Catharine & Marte, 2015) and have measurable effects on the development on executive functioning (Tran et al., 2019).

1.2. Background

1.2.1. Previous Cognitive Flexibility Research

Factors found to predict CF capacity include language (Jacques & Zelazo, 2005), intelligence (Colzato et al., 2006), socioeconomic status (Clearfield, & Niman, 2012), education (Peralbo-Uzquiano, et al., 2020; Constantinidou et al., 2012), and acculturation strategy (Lau, 2013). CF is popularly hypothesized to be enhanced by coordinating, monitoring, and switching between languages (Seçer, 2016). Yet, mixed findings exist: some studies find bilingualism to promote cognitive flexibility (Christoffels et al., 2015), while others report no evidence of bilingualism's efficacy as a CF-explanatory variable (Nicoladis et al., 2018; Stephanie et al., 2019). Explanations for these inconsistent findings are surmised to originate from bilingualism researchers not differentiating between different types of mental shifting (Pringle, 2014). The mental shifting bilingualism requires relies on selective attention mechanisms to regulate language activation (Aparicio et al., 2017). This top-down control enhances

convergent thinking (i.e., logical reasoning), not divergent thinking (i.e., creativity) (Hommel et al., 2011; Lavric et al., 2019). However, the type of mental shifting required to adapt across multiple cultural environments relies on the inhibition of top-down control to generate creative solutions and therefore, enhances divergent thinking rather than convergent thinking (Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009 as seen in Pringle, 2014). This hypothesis was supported by a study which found bilingual advantages on convergent thinking tasks such as the Stroop task but not other executive functioning tasks (Poulin-Dubois et al., 2011). In addition, Tran et al.'s (2019) study on the effects of bilingualism and culture in children's EF development showed bilingualism to effect cognitive control processes such as selective attention, switching and inhibition (e.g., dimensional shifting tasks) while culture effected behavioural regulation and response inhibition (e.g., verbal response inhibition tasks). As such, research suggests that it is not bicultural's ability to switch languages that promotes CF advantages but rather their ability shift and resolve incongruities between two cultural worlds and modes of thought (Ikizer & Ramirez-Esparza, 2018).

1.2.2. Cultural Cognitive Flexibility Research

The robustness of the CF - culture phenomenon has been demonstrated by numerous studies across different creativity measures (e.g., insight, association, generation etc.), and population samples, and cultural backgrounds (Maddux & Galinsky, 2009). Bicultural individuals showed enhanced creativity compared with monocultural individuals as measured by an alternative object uses task (Tadmor & Galinksy, 2012). Maddux and Galinsky (2009) proved time spent living abroad, but not time spent traveling abroad, positively correlated with CF capacity. This was assessed with the Duncker Candle Problem (Duncker, 1945), a measure of problem-solving ability, which presented individuals with a problem whose solution is inconsistent with pre-existing associations and expectations (Galinsky, Maddux, Gilin, & White, 2008; Maddux, Mullen, & Galinsky, 2008). Tadmor and Tetlock (2009) and Benet-Martínez and colleagues (2006) found biculturals to have greater CF as measured by their capacity for more nuanced and complex thought. When describing a problem related to culture or work, they were more likely to (1) view the situation from multiple perspectives, (2) accept these different perceptions as valid, and (3) compare and contrast various ideas (as seen in Gocłowska & Crisp, 2014).

1.3. Theoretical Frameworks

Previous studies investigating the relationship between culture and CF assumed a linear model of cultural acquisition and theorized *cultural frame-switching* to be the mechanism through which multiculturals managed their different cultural identities (LaFromboise et al., 1993). In other words, that individuals know and understand two different cultures will alternate their behavior depending on the situation (LaFromboise, et al., 1993). However, navigating the world successfully for extended periods of time requires a more coherent *sense of self* than frame switching allows (Gocłowska & Crisp, 2014). Therefore, *cultural frame-switching* is an unlikely explanatory model of the cognitive processes in individuals with more than one cultural identity. Instead, we hypothesize that the positive relationship between culture and CF may be underpinned by *schema violations* (Ritter, et al., 2014). Schema violation refers to encounters with events and ideologies that go against expectation. Piaget (1971, 1975) stated that when children experience an event incompatible with their existing worldview, a reconciliation process occurs where beliefs are altered to accommodate novel experiences (Gocłowska & Crisp, 2014). Crisp and Turner (2011) theorize this cognitive process to occur in adults exposed to multiple cultures and termed this process *inconsistency-resolution.* They speculate *inconsistency-resolution* to be responsible for CF strengthening and to consist of two main components. First, the inhibition of existing stereotypical knowledge (e.g., prior biases and assumptions). Second, the generation of novel ideas (e.g., divergent thinking and problem-solving). Thus, they hypothesized multiculturals, who repeatedly adapt to new cultural norms, to activate inconsistency-resolution processes more frequently. Through this propose Crisp and Turner suggest inhibition of biases towards stereotypes (top-down control) to become automated and thus greater capacity to exist for mental resources to be devoted to generative processes. This theory aligns with several studies which have proven that repeated encounters with situations which challenge one's stereotypical expectations improve the capacity to integrate conflicting cognitions and therefore leads to increases in creative capacities (Gocłowska, Crisp & Labuchagne, 2013; Huang & Galinsky, 2011; Miron-Spektor, Gino, & Argote, 2011; Wan & Chiu, 2002 as seen in Gocłowska, & Crisp, 2014). Consequently, for this paper we will view our findings through an inconsistency-resolution framework. No studies have previously tested CF capacity in multiculturals through this theoretical lens.

Aims and hypotheses. The aim of this paper is to test the relationship between growing up in different cultural environments and CF capacity, with the hypothesis that multicultural experiences

would positively predict higher cognitive flexibility. We tested our hypothesis by comparing performance on three CF measures (i.e., one lower order task, and two higher order tasks) between two types of cultural exposure (i.e., monoculturals and multiculturals). We used both linguistic proficiency and cultural exposure to classify participants into multicultural and monocultural participant groups. Lower order CF was measured with the Task Switching Paradigm Test (TSPT) (Roger & Monsell, 1995; Ravizza & Carter, 2008). The TSPT assesses the ability to rapidly shift one's attention between two tasks. Higher-order cognitive flexibility was measured with the Alternative Uses Task (AUT) (Wallach & Kogan, 1965), and Divergent Association Task (DAT) (Olson et al., 2021). Both the AUT and DAT assess the ability to generate novel solutions to simple problems.

1.4. Measurement and Theory Relationship

All three cognitive measures strongly reflect our theoretical research paradigm: inconsistency resolution. Recent research into the cognitive control mechanisms facilitating optimal creative thought reveal trade-offs occurring between two brain regions that allow for inhibition of stereotype bias and generative thought. These brain regions are the prefrontal cortex (PFC) (i.e., executive function), and posterior/subcortical brain regions (i.e., default mode network). This is because decreased PFC activity allows for reduced top-down control, and thus perceptual and associative information to have a greater influence on idea generation (Chrysikou & Thompson-Schill, 2011 as seen in Chrysikou, 2019). PFC inhibition has been shown to improve performance on an object uses task (Chrysikou et al., 2013 as seen in Chrysikou, 2019). Consequently, we chose the Alternative Uses Task (AUT) to measure CF in this study, particularly because the AUT's three sub-measures, flexibility, fluency, and originality, are all characteristics of inconsistency resolution (Crisp & Turner, 2011). Flexibility is a measure of category fluency (Gilhooly et al., 2007); how many object-use groups an individual's responses span. Flexibility therefore also captures inhibition capacity; the ability to suppress more obvious stereotypical responses. Fluency captures the ability to activate many unrelated thought processes and is indicative of generative capacity. Originality captures the degree of novelty in thought processes and is not related to PFC inhibition but rather to idea generation (Mayseless et al., 2015 as seen in Chrysikou, 2019). Next, TSPT captures inhibition capacity, the suppression of responses to previously activated stimuli. This close association between measurement and theory is an aspect often overlooked by other CF studies who fail to consider the robustness of their operationalizations. In other words, their CF definitions and theories

rarely map onto chosen measures. Our study's theoretical and measurement approach has several methodological advantages over previous CF research study designs. First, our choice in the experimental and control groups. Creating multicultural and monocultural participant groups allows cultural exposure differences to be maximized. This study design follows research in bilingualism where monolingual groups are used as a comparison to bilingual performance (De Houwer et al., 2014). Second, we selected populations with overarching cultural exposure patterns: heterogeneous and homogenous. This contrasts with previous studies which compare CF capacity between two specific cultures (e.g., North American and South African) (Cristine et al., 2018; LaRue et al., 1999), thus increasing the potential for our research findings to have global relevance.

2. Methods

2.1. Sample Selection

2.2.1. Recruitment

We recruited a total of 469 psychology undergraduate students from the University of Melbourne. A total of 66 men, 267 women, 4 non-binary, and 10 non-disclosures (Mage = 30 years) There were 32.4% native English speakers, 19.6% native Chinese speakers, and 47.97% other languages. Participants completed an experiment with a demographics survey and cognitive tasks. Recruitment occurred through Melbourne University's undergraduate Psychology research experience program. Students received course credit in return for survey completion. Melbourne University's Psychological Sciences Human Ethics Advisory Group gave ethics approval (195532.3; see Appendix J).

2.2.2. Inclusion Criteria

Participant classification as monocultural or multicultural occurred based on demographics survey responses. Monocultural participants were proficient in one language and had lived in one country before the age of 18. Multicultural participants had proficiency in at least two languages and had lived in at least three countries for a year before the age of 18.

2.2.3. Exclusion Criteria

Participant exclusion occurred when neither inclusion criteria were met. This maximized cultural exposure differences between participant groups. Our two participant groups were observationally different from one another. Inclusion criteria also captured a multicultural sample with

highly complex cultural identities. This level of complexity would not have been found in bicultural individuals.

2.2.4. Power analysis

To achieve large power ($1-\beta = 0.8$) at an alpha criterion of .05 with an effect size of 0.336 each participant group requires at least 140. Power analysis for an independent sample t-test determined this. This effect size was deemed appropriate based on a previous pilot study ($N = 20$) conducted using the same study design and participant criteria.

2.2. Measures

2.2.1. Demographics Questionnaire

A bespoke demographics survey was created to measure participants' cultural identity, ethnic heritage, cultural exposure, and linguistic ability (see Appendix A). A ten-point self-report scale assessed language skills. One indicated basic ability, six indicated linguistic proficiency, and ten indicated mother tongue. Participants listed the length of time lived in each country, and relocation age. Participants selected ethnic heritage(s): Caucasian, African, Asian, Caribbean, Hispanic or Latin, Arabic, Pacific Islander, Indigenous, or Other. Participants selected cultural identity/ identities: Anglo-American, Latin American, European, Slavic, Islamic, Sub-Saharan Africa, Indic, Sino-Japanese, Southeast Asian, Austral European, Insular Oceanic. This allowed for a novel and high-fidelity analysis of participants' socio-cultural backgrounds.

2.2.2. Cognitive flexibility Measures

Our study included three cognitive measures: TSPT, AUT and the DAT. One, TSPT, assessed lower-order CF processes, attentional control. Two, AUT and DAT, assessed higher-order CF processes, creativity.

Task Switching Paradigm Test. The TSPT is a commonly used measure of CF in neuropsychology (Hsieh, 2012). The TSPT assesses the capacity to shift attention between two tasks through reaction time comparisons. The TSPT has two block types, pure and mixed. Pure blocks contain homogeneous trials; each trial's stimulus is identical to the previous one. Mixed blocks are heterogeneous; trials contain two stimuli. Our mixed blocks follow Roger and Monsell's *alternative runs approach.* Two presentations of stimulus A (letter) follow two presentations of stimulus B (number) (Roger & Monsell, 1995; Jersild, 1927). Participants are asked to respond as fast as possible while minimizing mistakes. Participants followed two rules. (1) If the stimulus appears in the top quadrants,

respond to the letter. If the stimulus appears in the bottom quadrants, respond to the number. (2) Categorize letter stimuli as consonant (B key) or vowel (N key). Categorize number stimuli as odd (B key) or even (N key). Longer reaction times between trials where stimuli change versus trails where stimuli repeat represents low CF (Monsell, 2003).

Alternative Uses Task. A used and accepted measure of creativity and divergent thinking in psychology the AUT requires participants to generate as many uses as possible for a given household object. Participants are instructed to list as many and varied uses as possible for a given object in 2-minutes. In this study, five household objects were presented: brick, paperclip, towel, bottle, and match (preserving order). We scored the AUT for flexibility, fluency, and originality. Flexibility quantifies how many conceptual categories into which a participant's object-uses fit. Responses spanning a greater number of object-use categories receive greater scores in higher order cognitive flexibility. For example, if the uses listed for the object *brick* all belong to one category (e.g., gardening) the flexibility score will be lower than if the uses listed belong to several different categories (e.g., gardening, cooking, exercise). Fluency quantifies the number of object-uses a participant lists; responses with many object-uses listed receive larger fluency scores (i.e., greater higher order CF). Originality determines how rare a participant's object-uses are relative to the sample. Infrequently appearing object-uses receive larger originality score (i.e., greater high order CF). This AUT scoring method follows the practices in DeYoung et al. (2008).

Divergent Association Task. The DAT, although used to measure creativity, has never been applied to CF. In the DAT, participants are asked to generate 10 nouns that are as different from each other as possible, in all meanings and uses of the word, within four minutes. The chosen words had to either be single words or nouns (e.g., things, objects, concepts. These 10 words could not be proper nouns (i.e., no specific people or places), or specialized vocabulary (e.g., no technical terms). Responses are then scored using a GloVe model, which calculates average semantic distance between words based on the context with which the two words appear together. Word usage context was determined from a database of 2 million words constructed from billions of web pages (Olson et al., 2021). A higher number of semantically dissimilar nouns listed shows an increased capacity to make remote conceptual associations (i.e., higher CF) (Olson et al., 2021).

2.3. Procedure

Each participant was tested individually through the online survey platform PsyToolkit (Stoet, 2010; Stoet, 2017). First, participants read a plain language statement (see Appendix E) and signed a consent form (see Appendix F). Participants then completed the demographics questionnaire. The three cognitive flexibility tasks were then presented in counterbalanced order to participants. Short breaks between measures and sub-measures decreased mental fatigue. Practice rounds before experiments allowed participants to increase task familiarity and did not affect performance (Stoet & Snyder, 2007). After testing, participants read and signed a debriefing form (see Appendix G).

2.4. Data cleaning

Due to the online nature of the study, and the consequent inability to physically check for participants' consistent attention, we removed participants who made errors on greater than 20% of trials for any of the tasks. Data cleaning for the task switching paradigm test was performed in R (R Core Team, 2019) using the dplyr package (Wickham et al., 2021). We excluded the following data (1) trials with RTs longer than 5,000ms, as it may indicate participant distraction, (2) trials with response error (responses incongruent with a task type's requirements), and (3) trials following error trials to limit carry-over effects from incorrect responses. Responses that violated any of the four rules of the Divergent Association Task were removed (see Appendix I). If, after these responses had been removed, the participant had provided fewer than seven responses, this participant was also removed (as having made errors on greater than 20% of trials).

2.5. Statistical Analysis

2.5.1. Descriptives

Calculations of participants' mean, standard deviation, and kurtosis occurred for letter and number switch costs, fluency, flexibility, originality, and semantic distance. A Shapiro-Wilk test of normality and visual inspection of histograms determined the shape of the distribution.

Task Switching Paradigm Test. Switch costs were determined by subtracting repeat trial RTs from switch trial RTs. This was calculated within mixed blocks by stimulus type. Letter and number switch costs were calculated per participant. Letter switch trials were defined as RTs for transitions from

letter to number trials. Number switch trials were defined as RT for transitions from number to letter trials.

2.5.2. Inferential Analysis Methods

We compared differences between participant group performance across all three cognitive tasks. An independent sample t-test was used when data were normally distributed. The non-parametric Kruskal-Wallis test was used when data were non-normally distributed. Cohen's d and eta-squared were respectively used to calculate effect sizes.

3. Results

3.1. Study Sample

3.1.1. Sample Description

Out of the 469 participants recruited, the final analysis included 111 (*N*) participants (*n* = 51) monocultural and (*n* = 60) multiculturals. Multicultural's were 16.7 % male and 83.3% female (M^{age} = 18.81, SD^{age} = 1.65). Monocultural's were 31.4% male, and 70.6% female (M^{age} = 21.66, SD^{age} = 7.81).

3.1.2. Participant Selection

Both manual (i.e., Excel) and automated methods (i.e., R Core Team, 2019) identified incorrect, irrelevant, incomplete, elements of our dataset. Immediately 152 participants were excluded due to incomplete responses across many tasks. Lack of conformity to monocultural or multicultural inclusion criteria excluded another 205 participants. Next, inconsistent demographics responses due to spelling errors and prompt misunderstanding led to exclusion of 18 participants from the study. For the TSPT one participant was removed from the study. For the AUT's first exclusion criteria, the number of individual responses removed per object was: paperclip (6), brick (6), towel (25), bottle (6), and match (20). Following the AUT's second exclusion criteria, seventeen participants were removed from the study. For the DAT, we excluded 133 participants.

3.1.3. Participant Demographics

Asian and Caucasian were the most frequently reported ethnicities. Southeast Asian and Austral European were the most reported cultural identities. English and Chinese were the most spoken languages (see Figures 8, in Appendix H). Multicultural's identified a higher number of different cultural identities compared to monocultural's (see Figures 11, in Appendix H). For multiculturals, 51.66% identified with one cultural identity, 38.33% identified with two,

and 10.0% identified with three. For monocultural's 63.46% identified with one cultural identity, 34.61% identified with two, and 1.92% identified with three.

3.1.4. Data Inclusion

A Shapiro Wilk test of normality indicated letter TSPT data was not normally distributed. Observations greater than two Median Absolute Deviations (*MAD*) from the median were considered outliers and excluded. We defined our outlier set as observations greater than two median absolute deviations from the median. With this definition, 19.00% of the letter switch cost data was contained in the outlier set; *Median* = 417.43, *MAD* = 165.08. For number switch costs, 16.00% of the data was contained in the outlier set; *Median* = 305.30, *MAD* = 170.60. Therefore, we had reason to believe the data was not the result of a measurement error or experimental error but instead natural and the result of novelty in the data. Furthermore, after excluding outliers the letter switch cost still did not follow a normal distribution as determined with a Shapiro Wilk test of normality. As a result, data points were kept in the data as we determined they were a part of the data and not outliers.

3.3. Main Results

3.3.1. Task Switching Paradigm Test Descriptive Statistics

Table 1

Mean, Standard Deviation, and Kurtosis Performance Scores of Participants on the Task Switching Paradigm Test

Block	Monocultural Participants				Multicultural Participants			
Stimulus	M		SD	Kurtosis	M		SD	Kurtosis
Trial	RT	% Error*			RT	%Error*		
Letter								
Switch	1435.86	3.89	733.33	5.78	1274.98	3.26	605.05	7.29
Repeat	1028.94	3.62	651.98	10.78	885.83	3.03	495.71	15.05
Switch cost	282.83	-	292.47	-0.21	301.22	-	247.29	2.66
Digit								
Switch	1307.51	3.49	666.43	6.82	1176.09	3.04	587.29	11.14
Repeat	945.03	3.18	560.68	9.55	865.01	2.72	490.37	15.01
Switch cost	498.89	-	267.74	0.99	415.26	-	241.84	0.04

Note. For mixed blocks, mean, standard deviation, and kurtosis were organized by stimuli and trial transition type. Switch cost refers to differences in RTs between switch and repeat trials within mixed blocks. RT refers to reaction time as measured in milliseconds. % Error* refers to the percentage of trials that were incorrect or too slow. Higher positive values show longer RTs and worse CF.

[a]*n* = 51 for monoculturals and [b]*n* = 60 for multiculturals.

Measures of Central Tendency. Compared to monoculturals, multiculturals had lower RTs on the letter paradigm. Slightly higher RTs existed for multiculturals on the number paradigm versus monculturals. For both groups, RTs were greater for letters than numbers. As expected, for both groups, average letter and number switch trial RTs were longer than repeat trials.

Measures of Variability.

Normality. Violations of normality assumptions existed in some but not all instances. For letter switch cost a Shapiro Wilk test found no significant violations of normality for monoculturals ($W(51) = 0.99$, $p = .770$). Significant violations did exist for multicultural's ($W(60) = 0.92$, $p = .001$). For number switch cost a Shapiro Wilk test found no significant violations of normality for monoculturals ($W(51) = 0.98$, $p = .538$) or multiculturals ($W(60) = 0.99$, $p = .671$).

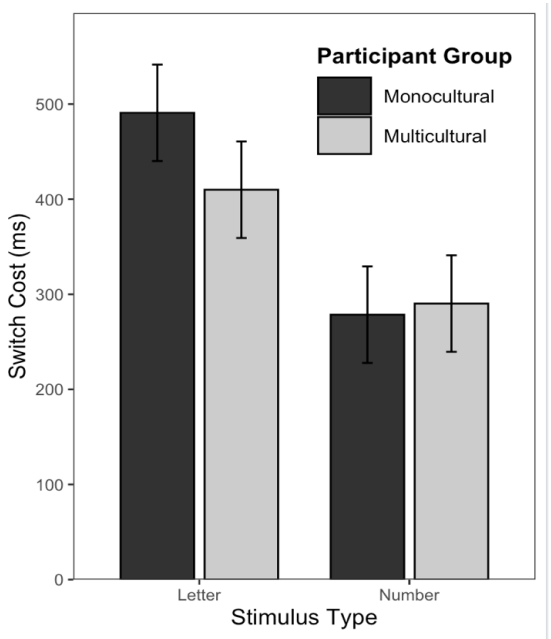
Accuracy. Although mean error rates were similar for participants, multicultural's error rate was slightly lower ($M^{multi} = 3.01$; $M^{mono} = 3.55$).

3.3.2. Task Switching Paradigm Test Inferential Statistics

Hypothesis 2 predicted multicultural's RTs would be lower than monocultural's (i.e., superior CF).

Figure 1

Mean Switch Cost Scores on Different Stimuli for Participants



*Note. M*ean letter and number switch cost is compared between multiculturals and monoculturals. Stimulus type refers to letter or number stimuli. Switch cost is measured in milliseconds (ms). Error bars show standard errors.

Letter. The Kruskal-Wallis test was significant with $H(1) = 3.86$, $p = 0.049$, and revealed significant differences between multicultural and monoculturals. Eta^2 revealed a small effect size, $r = 0.026$ (cite: package rstatix).

Number. A one-tailed independent samples t-test compared group effect on letter and number switch cost. Number switch costs had a $MD = 83.62$ms, and 95% CI [-12.28, 179.52]. Performance differences between groups was not significant; $t(109) = 1.73$, $p = .087$, $d = 0.33$. This represents a small effect size for number switch costs (Cohen, 1988).

3.4. Secondary Results I

3.4.1. Alternative Uses Task Descriptive Statistics

Table 2

Mean, Standard Deviation, and Kurtosis Performance Scores of Participants on the Alternative Uses Task and the Divergent Association Test

Measures	Monocultural participants			Multicultural participants		
Sub-measures	*M*	*SD*	*Kurtosis*	*M*	*SD*	*Kurtosis*
DAT	78.82	6.76	0.72	80.19	5.12	3.89
AUT						
Fluency	6.69	3.19	0.10	6.51	2.64	-0.19
Flexibility	4.34	1.74	-0.22	4.49	1.4	-0.58
Originality	0.83	0.83	0.48	0.84	0.73	0.79

Note. Mean, standard deviation, and kurtosis for fluency, flexibility, originality, and semantic distance. Greater values show superior CF.

[a]$n = 51$ for monoculturals and [b]$n = 60$ for multiculturals.

Alternative Uses Task Descriptive Measures of Central Tendency. Multiculturals outperformed monoculturals on originality and flexibility but not fluency. Across groups, fluency scores ranged from 1.2 to 15 words, flexibility ranged from 0 to 7.8 categories and originality ranged from 0 to 3 in rarity.

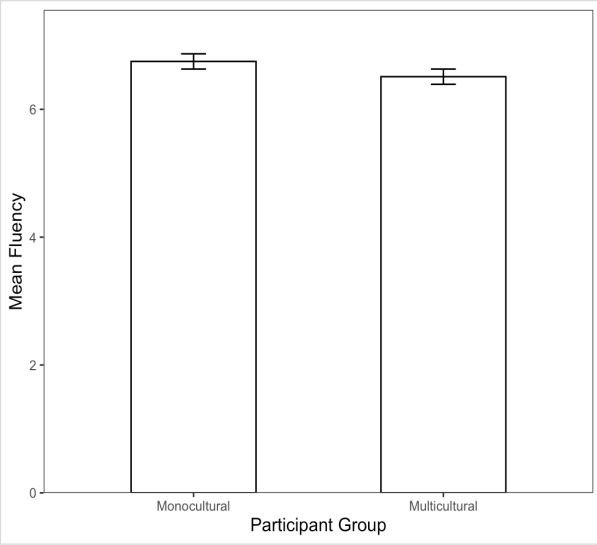
Alternative Uses Task Measures of Variability.

Normal Distribution. Monocultural's fluency distribution did not vary significantly from normal ($W(1) = 0.96$, $p = .093$), multiculturals' did ($W(1) = 0.95$, $p = .017$). Flexibility distributions did not vary significantly from normal for both multiculturals ($W(1) = 0.98$, $p = 0.445$) and monoculturals ($W(1) = 0.98$, $p = .739$). Originality distributions were significantly different from normal for both monoculturals ($W(1) = 0.86$, $p < .001$) and multiculturals ($W(1) = 0.89$, $p < .001$).

3.4.2. Alternative Uses Task Inferential Statistics

Figure 2

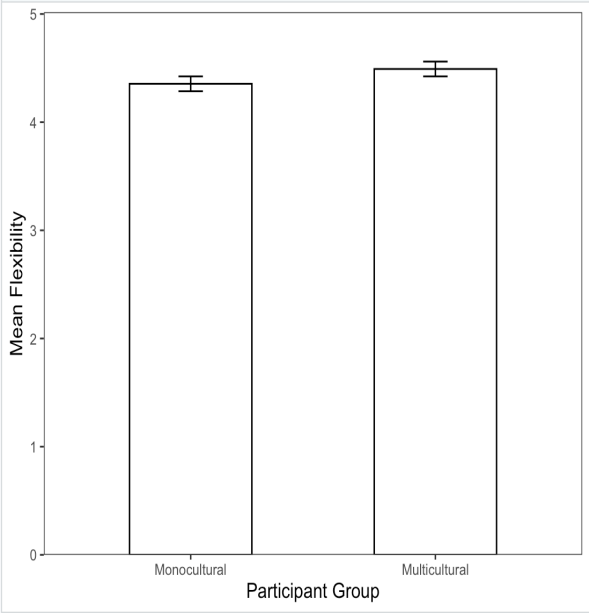
Mean Fluency Scores for Participants



Note. Mean fluency scores differences between monocultural and multiculturals.

Figure 3

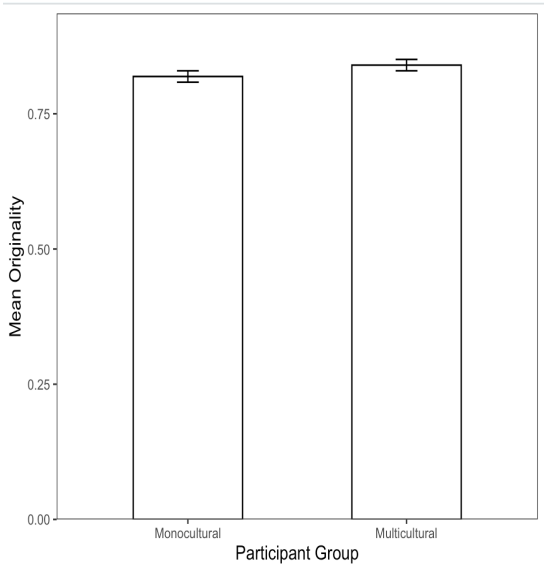
Mean Flexibility Scores for Participants



Note. Mean flexibility scores differences between monocultural and multiculturals.

Figure 4

Mean Originality Scores for Participants



Note. Mean originality scores differences between monocultural and multiculturals.

Hypothesis 3 predicted all multicultural AUT subscores would be higher than monoculturals'. Significant differences existed between monocultural and multicultural's fluency and originality scores.

Flexibility. Flexibility differences had a *MD* = -0.14ms, and 95% CI [-0.73, 0.46]. An independent samples t-test showed flexibility differences were not significant ($t(109) = -0.46$, $p = .648$, $d = -0.086$). This represents a negligible effect size for flexibility (Cohen, 1988).

Fluency. Fluency differences had a *MD* = 0.24ms, and 95% CI [-0.86, 1.34]. A Kruskal-Wallis test showed fluency differences were not significant ($H(1) = 0.07$, $p = .797$).

Originality. Originality differences had a *MD* = -0.02ms, and 95% CI [-0.31, 0.27]. A Kruskal-Wallis test showed fluency differences were not significant ($H(1) = 0.281$, $p = .596$).

3.4. Secondary Results II

3.4.1. Divergent Association Task Descriptive Statistics

Divergent Association Task Measures of Central Tendency. Average semantic distance across all participants was M = 79.59. Multiculturals had a greater mean ($M^{multi} = 80.91$; $M^{mono} = 78.82$). Monoculturals had a greater SD ($SD^{mono} = 6.76$; $SD^{multi} = 5.12$).

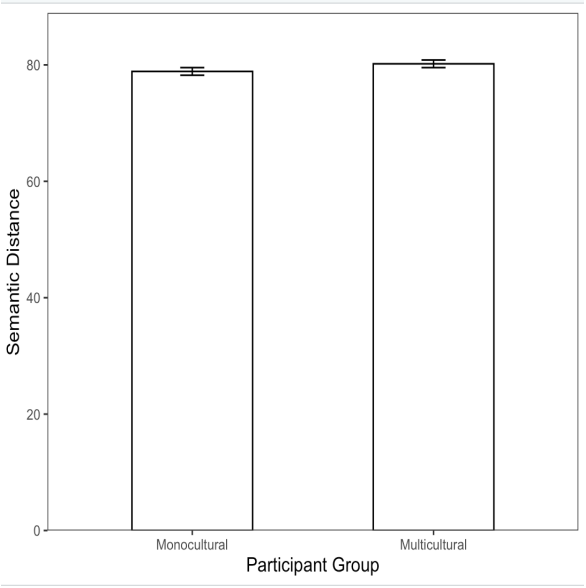
Normal Distribution. Monocultural's semantic distance was not significantly different from normal ($W(1) = 0.98$, $p = .038$). Yet multicultural's semantic distance distribution was significantly different from normal ($W(1) = 0.93$, $p = .002$).

3.4.2. Divergent Association Task Inferential Statistics

We predicted that multicultural's semantic distance (DAT scores) would be higher than monocultural's. Semantic distance had a MD = -1.31ms and 95% CI [-3.57, 0.94]. A Kruskal-Wallis test indicated differences between monocultural's and multicultural's scores were not significant at $H(1) = 1.57$, $p = .210$.

Figure 5

Mean Semantic Distance Scores for Participants



Note. Mean semantic distance for monoculturals and multiculturals.

3.5. Correlational Analysis

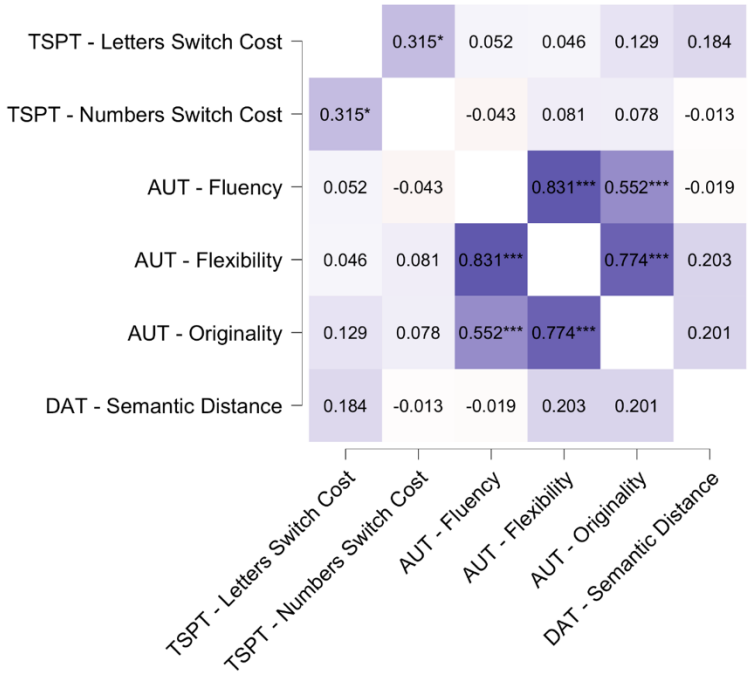
Correlational analyses were used to assess relationships between task performance with multicultural and monocultural participant groups, respectively.

3.5.1. Multicultural Correlation

For multiculturals, as expected, strong positive correlations exist between each tasks sub-measures (i.e., AUT & TSPT). However, no correlations exist between different tasks sub-measures (i.e., DAT, AUT and TSPT). See Figure 6.

Figure 6

Heatmap of Sub-measure Score Correlations for Multiculturals



Note. Correlations between cognitive task (TSPT, AUT, DAT) sub-measures for multiculturals.

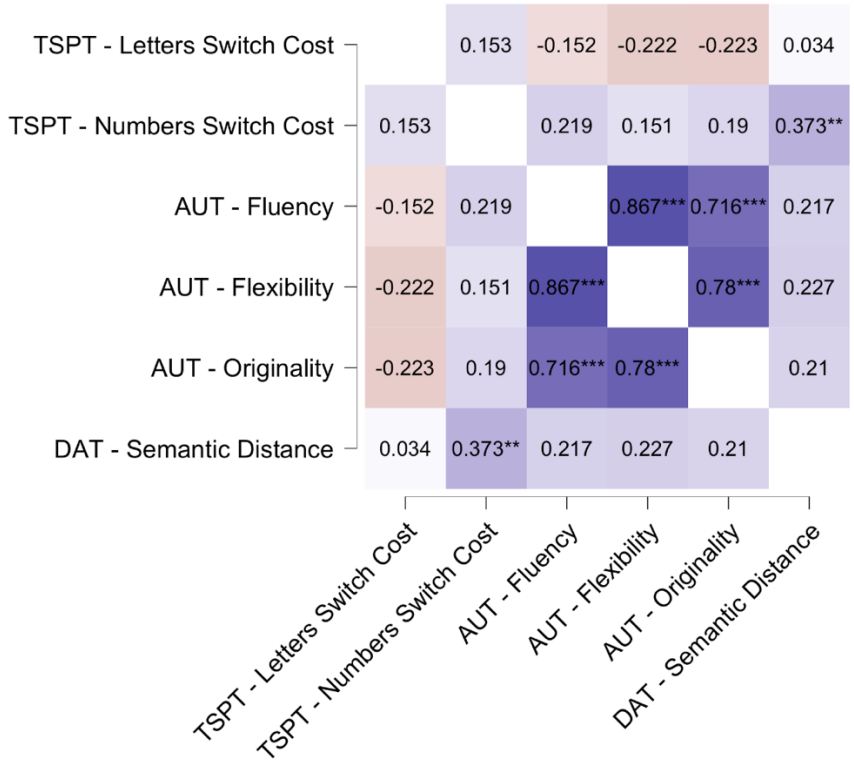
*$p < .05$. ** $p < .01$. *** $p < .001$.

3.5.2. Monocultural Correlation

As expected, for monoculturals, significant correlations exist within each tasks submeasures (i.e., TSPT, AUT). More interestingly, significant correlations existed between semantic distance an

Figure 7

Heatmap of Sub-measure Score Correlations for Monoculturals



Note. Correlations between cognitive task (TSPT, AUT, DAT) sub-measures for monoculturals.
*$p < .05$. ** $p < .01$. *** $p < .001$.

4. Discussion

Higher multicultural scores are theoretically linked with a heightened CF capacity as multicultural individuals are constantly required to resolve incongruities in their daily lives. This heightened CF capacity enables attention to pivot between tasks, and novel problem-solution generation. Our research investigates relationships between CF capacity and multicultural exposure. We compared impacts of mixed versus constant cultural backgrounds on lower and higher CF. We hypothesized multiculturals to have superior lower and higher CF scores. While we found that multiculturals outperformed monocultural's on most measures, there was only one in which this difference was significant. Only one significant difference existed: multiculturals outperformed monoculturals on TSPT's letter subscores. These non-significant results may be due to our sample size being smaller than our pilot's power analysis indicated. A limitation was not accounting for psychological differences within multiculturals.

Multicultural's acculturation strategy and personality traits impact on CF needs further research. Our results show promise for culture as a theoretical lens for further CF inquiry, and makes way for a new research question: What specific aspects of multicultural exposure lead to CF strengthening? Future research should strive to illuminate underlying mechanisms which enable CF capacities.

4.1. Lower Order Cognitive Flexibility: Multiculturals Compared to Monoculturals on the Task Switching Paradigm Test

Performance on the TSPT was distinct in letter compared to number subscores between the groups. Multicultural's TSPT letter subscores were significantly lower than monocultural's. This finding may capture a true multicultural CF advantage, or represent a chance finding, a statistical artifact. Non-significant differences existed between monocultural's and multicultural's TSPT number subscores. This similarity in TSPT number performance is counter to expectation; the cause is not clear.

4.1.1. TSPT Context

These findings are in line with Legare and colleagues (2018) paper, which analyzed cultural differences in CF by comparing performance between American and South African children on the 3DCCS (i.e., a rule-switching test). After finding age-related increases in rule-switching flexibility in American children but not South African, they hypothesized that rule-switching flexibility might be more dependent on particular types of cultural experiences.

4.1.2. TSPT Explanation

Practice effects may explain the similarity in performance between the two groups in terms of number scores, particularly compared to letter scores. Mathematical education generally includes the categorization of numbers into odds and evens. Letters are rarely categorized into vowels and consonants. Thus, number skill sets may confound cultural exposure influences on TSPT performance for both groups. For the TSPT letter task, multiculturals outperform monoculturals despite decreased letter stimuli familiarity. Chinese is the first language of ~70% of multiculturals in the current study and would presumably be linked with less fluency with Roman alphabets. In contrast, English is the first language of ~70% of monoculturals, and thus predicts high fluency with Roman alphabets. From the perspective of our inconsistency-resolution theoretical framework, superior letter scores demonstrate multicultural's superior ability to (1) suppress pre-existing knowledge and consequently to remain flexible enough to (2) pivot to a new problem-solving strategy (when the stimuli changes). The

automated inhibition allows multiculturals' to have lower switch costs because they will make fewer assumptions as to what trial type the next trial will be.

4.2. Higher Order Cognitive Flexibility: Multiculturals Compared to Monoculturals on the Alternative Uses Task

Non-significant differences existed between monoculturals and multiculturals on their respective AUT subscores. Yet, score patterns support our hypothesis and research paradigm. Congruent with our hypothesis multiculturals have higher flexibility and originality scores. Incongruent with our hypothesis, monocultural's have higher fluency scores. These findings support our research paradigm.

4.2.1. AUT Context

These findings are in line with Çelik and colleagues (2016) paper which showed that value diversity (i.e., multiculturalism) positively predicted originality (i.e., uniqueness of ideas) on Guilford's (1967) alternative uses task. Yet our study's results are different from theirs in that we did not find multiculturalism to positively correlate with fluency scores. However, this lack of correlation between multiculturalism and fluency was also found in Fee and Gray's (2012) results. Their study showed expatriate experience to result in significant increases in flexibility, but not in fluency and originality (as seen in Aytug et al., 2018).

4.2.2. Flexibility AUT Finding Explanation

The superior flexibility scores demonstrated by multiculturals may be due to increased inconsistency resolution experiences. Flexibility is the number of object-use categories a set of responses contain. Multicultural's may have an increased ability to suppress expectation, an inconsistency resolution component. This advantage may stem from a need to inhibit prior social norms expectations to adapt to a new culture. This inhibitory capacity may lead to advantages in suppression of common object-uses in favor of novel ones. Monoculturals function in cultural environments in which social norm expectations are rarely challenged. Thus, their inhibitory capacity may be less developed, and the participants respond with object uses that are more common.

4.2.3. Fluency AUT Finding Explanation

English proficiency differences may explain monoculturals superior fluency scores. Fluency is the number of object-uses listed. We theorize language skill level to influence fluency over CF capacity in time-pressured environments. Multiculturals speak two or more languages, predicting lower English proficiency than monoculturals. Multicultural's slower vocabulary retrieval speed may result in fewer object-uses listed. Thus, fluency may not accurately measure CF since word retrieval speed is a confounding variable.

4.2.4. Originality AUT Finding Explanation

Multicultural's cultural exposure and inconsistency resolution experiences may explain originality scores. Multiculturals have seen objects implemented in a variety of cultural contexts. Bicultural identities have been shown to result in a widening of one's creative idea base (Gocłowska & Crisp, 2014). Monoculturals have only experienced object use within one cultural context. Thus, multiculturals may integrate divergent object-use conceptualizations and produce more novel answers. Multicultural's superior originality may be due to inconsistency resolution experiences strengthening generative thinking. Inconsistency resolution requires individuals to think in subjective and relative ways. This sensitivity to perspectives may improve capacities to combine concepts in novel ways. Monoculturals low inconsistency resolution may limit the generation of nuanced perspectives which creates originality.

4.3. Higher Order Cognitive Flexibility: Multiculturals Compared to Monoculturals on the Divergent Association Task

We found that multicultural's demonstrated an ability to draw on words with greater semantic distance compared to monoculturals.

4.3.1. DAT Context

These results are consistent with research investigating differences in creativity between bilingual and monolingual individuals the Figural Form A of the Torrance Test of Creative Thinking. Results showed bilinguals to have superior originality scores in comparison to monolinguals (Torrance et al., 1970). The finding that multiculturals performed higher than monoculturals on both the DAT and AUT is in line with Olson and colleagues (2020) study which showed that individuals who score highly on traditional creativity measures also produce greater semantic distances.

4.3.2. DAT Finding Explanation

Differences in participant groups' knowledge of multiple languages may affect semantic distance between words listed. This may explain multicultural's superior scores. Greater proficiency in a language lead to semantic networks being more developed. Multicultural's lower English proficiency may make their semantic network size smaller. Smaller semantic networks may make word associations less automatic. Thus, listing dissimilar nouns for multiculturals may be easier. Monocultural's larger semantic networks may make listing dissimilar nouns harder. Semantic network size may be a confounding variable hindering accurate CF measurement with the DAT. See Table 2, and Figure 5.

4.4. Relationships Between Lower Order and Higher Order Cognitive Flexibility Tasks

Although there were significant correlations within measures, of most interest are the correlations between measure subscales. Significant correlations within measures were expected since the AUT and TSPT measures have internal validity (i.e., all sub-tasks are assessing the same construct). Correlational differences exist between DAT and TSPT number scores for monocultural's but not multiculturals ($r^{mono} = 0.37$; $r^{multi} = -0.013$). We do not have an explanation for this finding.

4.5. Limitation

Online testing of cognitive measures using reaction time outside a lab raises data reliability and accuracy concerns (Holden et al., 2019). This is particularly true for reaction time measures such as the TSPT. Concerns are negated because of the TSPT's relative scoring method. Switch cost calculations are based on participant's repeat and switch trials RTs. Potential impacts of hardware on RTs (e.g., monitor display times, computer processing speed) are controlled. Participants completing the experiment in an uncontrolled setting raises data accuracy concerns. Environmental variability (e.g., distractions, time of day, etc.) can introduce noise into results. A recent paper by Sliwinski and colleagues (2016) shows results from a brief ambulatory cognitive assessment of perceptual speed and working memory were both reliable and valid between participants.

4.5.1. Strengths

Demographics. First, our demographics survey measures culture more accurately than typical cultural surveys. This is because our survey separates cultural identity from ethnicity. This enables the construction of detailed cultural narratives. Second, incorporating a control group (i.e., monoculturals) is rarely done in cultural studies and adds validity to our findings.

Theoretical Framework. Our study is the first to experimentally test the theory of inconsistency resolution as a mechanism for CF strengthening. Our study is also the first to use the meta-competency definition of CF proposed by Bockelmann and colleagues (2021).

Study Design. Our study demonstrates the TSPT holds validity as an online, at-home, CF measure because of its relative scoring method. Our study is the first to incorporate measures for both higher and lower-order CF capacity in the same study. This enabled us to explore multicultural experience effects on different aspects of CF.

4.5.2. Limitations

Main study limitations include sample size, and not accounting for variation within participant groups.

Data Collection Period. Covid-19 stressors may have decreased detection of CF capacity differences between groups. Data collection occurred during a severe lockdown in Melbourne, Australia (i.e., April - September 2020). Covid-19 restrictions produced an immense amount of population-level stress in Australia (Jill et al., 2020). Stress negatively impacts CF performance, particularly task-switching (Goldfarb et al., 2017). CF depends on a brain region (i.e., prefrontal cortex) easily impaired by stress.

Population Sample. Not considering data-collection location impacts on sample characteristics caused sampling errors. Our results did not represent our true population of interest. Melbourne's Asian community caused domination of Asian and Austral European sample characteristics. Our multicultural's bicultural ethnic, and linguistic patterns reveal low sample diversity. Low cultural diversity may mean our study shows bicultural, not multicultural, influences on CF capacity. Melbourne's Asian community may result in monocultural's CF capacities resembling biculturals. Decreased cultural exposure differences between groups may contribute to our non-significant findings.

Cultural Distance. Not measuring cultural distance introduced a conceptual error. Cultural distance is the degree of difference between two cultures calculated from societal values (Shenkar, 2012). We assumed multicultural's inconsistency resolution experiences to be uniform and therefore equally strengthen CF capacity. Yet, we overlooked a variable influencing frequency of inconsistency resolution, cultural distance. Integrating cultural frameworks with similar values, and beliefs requires less inconsistency resolution. Therefore, multicultural's with small cultural distances may not strengthen

CF to the same degree. Not controlling for cultural distance may contribute to non-significant participant group differences.

Sample Characteristics. Unaccounted for psychological variation within the multicultural sample introduced conceptual error. Evidence shows experience-seeking personality traits (extraversion and openness) to be predictive of individuals leading successful multicultural lifestyles (Harari et al., 2018). Thus, our study may capture a sample whose personality traits, and not environmental exposure, allows for higher CF. It is unclear. Evidence reveals a correlation exists between acculturation type and CF (Roccas & Brewer, 2002; Yampolsky et al., 2016). Acculturation type affects psychological stress and therefore impacts CF; lower acculturation is related to higher stress which has been shown to impede cognitive flexibility (Bae, 2020). Identity integration confers CF capacity benefits but not identity compartmentalization (Spiegler & Leyendecker, 2017). Thus, acculturation style may impact CF strengthening independent of cultural environment.

Language Dependent Measures. Including language-dependent measures (i.e., AUT and DAT) was a conceptual error. This error made it difficult to determine if scores were due to language skills or CF capacity.

4.6. Future Research

4.6.1. Population Sample

Future studies should recruit monocultural's from a location with no external cultural influences. Multicultural recruitment should occur at international schools to ensure diverse cultural environment influences.

4.6.2. Cultural Distance

Follow-up studies should measure cultural distance between the countries multicultural's have lived. Hofstede's cultural distance calculator would be a good tool (see website: http://www.culturaldistance.com). Founded on Hofstede's cultural dimension theory, this tool uses average national scores from the World Values Survey. This survey assesses participant's views on work, family, politics, and religion (De Santis et al., 2016). For example, more similar views between New Zealand and Australia mean low cultural distance. Measuring cultural distance would allow better prediction of the frequency of participants' inconsistency-resolution experiences.

4.6.3. Sample Characteristics

Future studies should include the Big Five Aspects Scale to measure personality traits (DeYoung et al., 2007). This allows us to determine which psychological characteristics correlate with CF advantages. We expect positive associations to exist between CF and both openness and extraversion (Harari et al., 2018). Evidence has shown openness to correlate with education and intelligence (Schretlen, 2010). Both of these attributes correlate with creativity (Bond, 1981), which we define as higher order CF. To account for acculturation, future studies should include the Multicultural Identity Integration Scale (Yampolsky et al., 2016). This measure assesses how participants organize their cultural identities within the self. Independent of the participant group, we predict correlations between identity integration and CF (Tadmore & Tetlock, 2009).

4.6.4. Measure Selection

In future studies, shape and color stimuli should replace number and letter stimuli on the TSPT. This will remove digit practice effects and English proficiency as confounding variables. Future studies should exclude fluency and semantic distance scores. Performance on both is dependent on language capacity which hinders CF measurement.

4.7. Conclusion

4.7.1. Findings

Despite limitations, our results speak to multicultural CF meta-competency advantages. Superior multicultural CF at both lower and higher-order CF levels versus monoculturals. Significant differences on the TSPT number task demonstrate this advantage most clearly. Our results support our hypothesis that multicultural environment exposure increases CF capacity.

4.7.2. Implications

This paper provides a new approach to CF research and represents a shift in theoretical framework in the research field. Firstly, despite insignificant findings, our theorical *meta-competency* framework for CF is more comprehensive and holistic compared to other extant frameworks. Our finding that a positive association existed between performance on lower and higher order measures provides support for the efficacy of our CF meta-competency theory. More specifically, our study may show that multicultural environments strengthen CF at both higher and lower order CF levels simultaneously. Secondly, our findings support our research model's theoretical validity, above language-only paradigms. This is because our proposed mechanism of CF strengthening, *inconsistency resolution*, more realistically represents multicultural's lived experience. The more commonly used frame-switching

mechanisms focuses exclusively on language and thus ignores key cognitive attributes of multiculturals' that may positively influence CF development. Thus, our study's findings support *inconsistency resolution* as a mechanism of CF strengthening over *cultural frame-switching.* Overall, our results demonstrate exposure to multiple social-cultural environments can improve cognition because it forces individuals to consider things from fresh and different perspectives - a vital skill for adaptation and creativity (Spiegler & Leyendecker, 2017).

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6. Appendix

6.1. Appendix A

Demographics Questionnaire

Cultural Identity. Participants stated cultural identities based on the following definition: "(1) a group towards which you have a feeling of belonging, and (2) a group which is part of your sense of self-concept" (Guerrero et al., 2017). Defining cultural identity captured which cultural rules individuals have internalized and which cultures have influenced the way individuals relate to the world and themselves. A World Cultural Regions Map helped catalog individuals into distinct cultural identity, participants.

Figure 1

World Cultural Regions Map

Note. The World Cultural Regions map demarcates 11 ethno-cultural spheres according to shared religious, historic, linguistic and socio-economic features: Insular Oceanic, Latin America, Anglo-American, European, Islamic, Slavic, Sub-Saharan Africa, Indic, Sino-Japanese, Southeast Asian and Austral European.

The World Cultural Regions Map (see Figure 1) separates the world into ethnocultural spheres based on eight categories: race, religion, language, economic unionism, folk, habit/diet, dress, and belief (orthodox/ scientific). Categorizing individuals into cultural groups based on the world map's ethnocultural regions was more effective and meaningful than a geographic map; many cultures defy the

political agreements forming a country's boundaries. The relative simplicity of the World Cultural Regions Map facilitates the researcher's ability to include culture as a variable in research (Cultural region of the World UPSC (Human Geography), 2021).

Ethnicity. Participants were asked to indicate their ethnicity, defined as "purely genetic heritage", or in other words, the descendants of a common ancestor, or a group of people with distinct physical and genetic traits or characteristics passed on through birth (citation). Participants were presented with the following nine ethnic categories: Caucasian, African, Asian, Caribbean, Hispanic or Latin, Arabic, Pacific Islander, Indigenous and Other. These ethnic categories were adapted from a standard American census survey to fit this study's research needs (cite). To increase precision several ethnic categories could have been further subdivided according to linguistic or geographic origin however the demographics survey was nonetheless designed in this simplified manner to increase the feasibility of summarising our dataset.

6.2. Appendix B

Alternative Uses Task Instructions

Task instructions: “The following is a commonly used test of creativity and problem solving. Five common household items will be presented to you. Please list as many (and varied) uses as you can think of within 2 minutes.”

Object 1: Brick

_____

Object 2: Paperclip

_____

Object 3: Towel

_____

Object 4: Bottle

_____

Object 5: Match

_____

6.3. Appendix C

Divergent Association Task Instructions

Task Instructions: “Please enter 10 words that are as DIFFERENT from each other as possible, in all meanings and uses of the word. Rules: 1. Only single words. 2. Only nouns (e.g., things, objects, concepts). 3. No proper nouns (i.e., no specific people or places). 4. No specialized vocabulary (e.g., no technical terms). 5. Avoid using any specific strategy to choose the words. 6. You will have 4 minutes in total.”

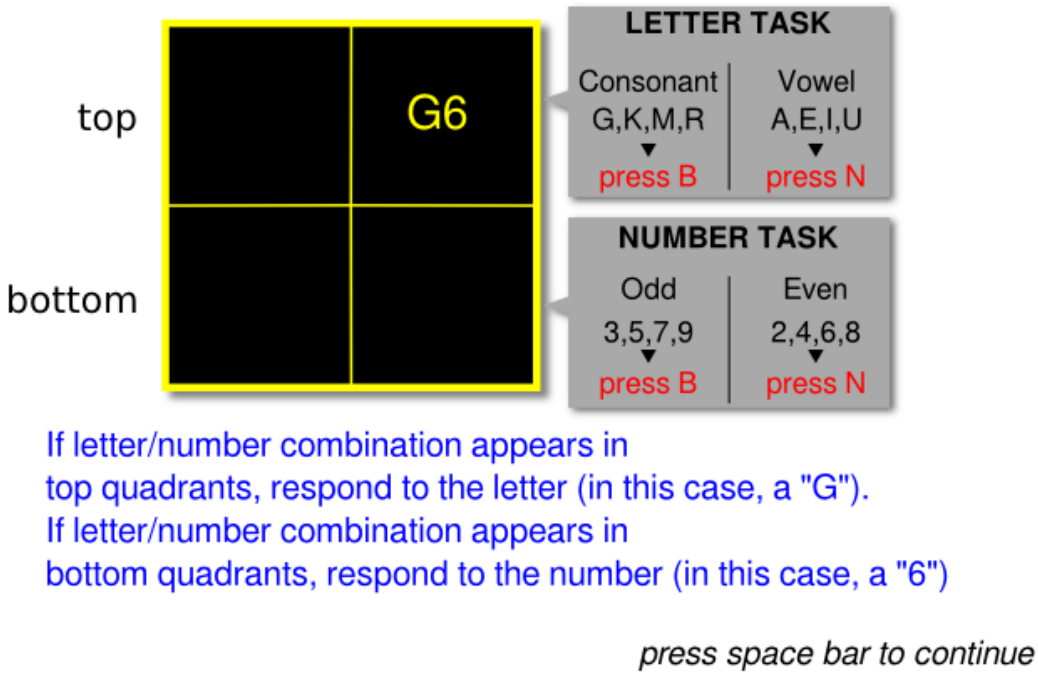
1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

6.4. Appendix D

Task Switching Paradigm Test Instructions

Task instructions: “If the letter/number combination appears in top quadrants, respond to the letter. If the letter/number combination appears in the bottom quadrants, respond to the number.” For the letter task they were instructed to press B when the letter was a consonant, and to press N when the letter was a vowel. For the number task they were instructed to press B when the number was odd and to press N when the number was even. Participants were told to “try to respond fast and try to make few mistakes.”

Figure 1



Note. This figure shows the instructions given to participants on the task switching paradigm test.

6.5. Appendix E

Melbourne School of Psychological Sciences

Plain Language Statement

PROJECT TITLE: Differences in cognitive processing in multi-cultural individuals

Dr. Margaret Webb (Principal Researcher) email: margaret.webb@unimelb.edu.au
Pascale Bockelmann email: pascale.bockelmann@mail.mcgill.ca
Samuel Veissière email: samuel.veissiere@mcgill.ca
Sujai Thomman email: sujai.thomman@unimelb.edu.au

Introduction
We would like to invite you to participate in a project investigating the impact of growing up in different cultural environments (i.e. growing up in different countries) on cognitive flexibility, problem solving and creativity.
What I will be asked to do?
You will be asked to complete three tasks on cognitive flexibility, problem-solving and creativity. The experiment is expected to take approximately 1 hour.
What are the risks?
There are minimal risks, and though our tasks are not tests, there is a possibility that you will become mentally fatigued during the experiment. There have been regular breaks inserted between trials. Please use these. In the event that you find your mood is negatively affected, please contact a psychology counselling service such as LifeLine (+61 13 11 14) in Australia. If you are participating from a different country we would recommend seeking similar services. For example:

- India: Lifeline (+91 33 2474 4704)
- Canada: Crisis Service Canada (+1 1833-456-4566)
- New Zealand: Lifeline (+64 0800 543 354)
- United Kingdom: Samaritans (+44 116 123)
- United States: Samaritans (+1 1-800-273-8255)

How will my confidentiality be protected?
The data collected from this project will be used for research purposes only. Every effort will be made to ensure your information will be kept in the strictest confidence. All experimental data will be stored in de-identified computer files in accordance with the guidelines set forth by the University of Melbourne for storing confidential information. De-identified results may be presented at relevant conferences, written up for publication in academic journals, and made available online for reliability checks. All data gathered for the purpose of this experiment will be de-identified after 5 years.

What if I want to withdraw from the Research?
Participation in this research is completely voluntary. You are free to withdraw at any time and to withdraw any unprocessed data previously supplied. This would have no effect on your relationship with any member of the School of Psychological Sciences. It would not affect your grades, assessment or any treatment that you would otherwise be eligible for.

Where can I get further information?
If you have not understood any of this information please contact any of the researchers listed above. This research has been cleared by the Human Research Ethics Committee (1954735.1, December 2019). If you have any concerns about this project please contact the Executive Officer, Human Research Ethics, The University of Melbourne (Tel: 8344 2073; Fax: 9347 6739).

How do I agree to participate?
If you wish to participate please read and sign the consent form that you will now be provided with.

6.6. Appendix F

Melbourne School of Psychological Sciences

Consent form for persons participating in a research project

PROJECT TITLE: Differences in cognitive processing in multi-cultural individuals

Contact details of researchers:
Margaret Webb (Principal Researcher) email: margaret.webb@unimelb.edu.au
Pascale Bockelmann email: pascale.bockelmann@mail.mcgill.ca
Samuel Vessiere email: samuel.veissiere@mcgill.ca
Sujai Thomman email: sujai.thomman@unimelb.edu.au

1. **I consent to participate in this project. The purpose of this research is to investigate possible differences in creativity, problem solving, and executive functioning in individuals who have lived experience in different cultures during critical developmental periods (i.e., between the ages of 0-18 have spent time in multiple different cultural environments).**

2. **I understand that this project is for research purposes only and not for treatment.**

3. **In this project I will be required to respond to some cognitive tasks. The details of this have been explained in the Plain Language Statement, of which I have been given a copy to keep.**

4. **I understand that there are risks involved in participating in this research project. Specifically, fatigue. These risks have been minimized by frequent breaks throughout the experimental design.**

5. **My participation is voluntary and that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided. Withdrawing from the project will not affect my relationship with the Melbourne School of Psychological Sciences.**

6. **I have been informed that the data from this research will be stored at the University of Melbourne and will be de-identified after 5 years.**

7. **I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements; my data will be password protected and accessible only by the named researchers.**

8. **I agree to have the findings of this study emailed to me.**

9. **I understand that after I sign and return this consent form, it will be retained by the researcher.**

My email address is:

6.7. Appendix G

Melbourne School of Psychological Sciences

Debriefing Statement

PROJECT TITLE: Differences in cognitive processing in multi-cultural individuals

Contact Details of All Researchers
Dr. Margaret Webb (Principal Researcher) email: margaret.webb@unimelb.edu.au
Pascale Bockelmann email: pascale.bockelmann@mail.mcgill.ca
Samuel Veissière email: samuel.veissiere@mcgill.ca
Sujai Thomman email: sujai.thomman@unimelb.edu.au
Ethics ID Number: 1954735.1

Thank you for participating in a project on cognitive flexibility, creativity and problem solving. This research aims to investigate possible differences in creativity, problem solving, and executive functioning in individuals who have lived experience in different cultures during critical developmental periods.

You have completed a series of three tasks. In the first, cognitive flexibility task, we were interested to see the average response time between switch and non-switch trials, we assumed that the faster your response time the lower your cognitive load and the slower your response time the higher your cognitive load. In the second, creativity task, we were interested to see how different your responses were from one another with respect to their meaning. In the third, problem solving task, we were interested to see how many different possible uses you could generate for a given object, how original these uses were and how different these uses were.
If you found yourself worried during the experiment, please contact a psychology counselling service such asc (Australia: +61 13 11 14) or the University of Melbourne Psychology Clinic (Tel: +61 3 9035 5180; email: clinic@psych.unimelb.edu.au). If you are participating from overseas, the following free counselling services may be applicable:

-
  - India: Lifeline (+91 33 2474 4704)
  - Australia: Lifeline (+61 13 11 14)
  - Canada: Crisis Service Canada (+1 1833-456-4566)
  - New Zealand: Lifeline (+64 0800 543 354)
  - United Kingdom: Samaritans (+44 116 123)
  - United States: Samaritans (+1 1-800-273-8255)

This research has been cleared by the Human Research Ethics Committee (1955321.1, December 2019). If you have any concerns about this project please contact the Executive Officer, Human Research Ethics, The University of Melbourne (Tel: +61 8344 2073).

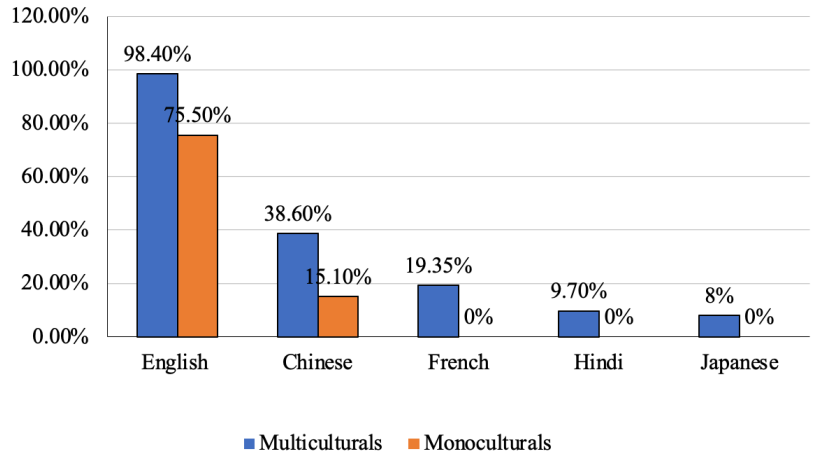
6.8. Appendix H

Demographics Analysis Results

Languages. Multicultural's linguistic diversity (i.e., number of languages spoken) exceeded monocultural's (see Figure 5). Most commonly spoken languages were English (mulit = 98.4%, mono = 75.5%) and Chinese (multi = 38.6%, mono 15.1%).

Figure 8

Most Common Participant Languages

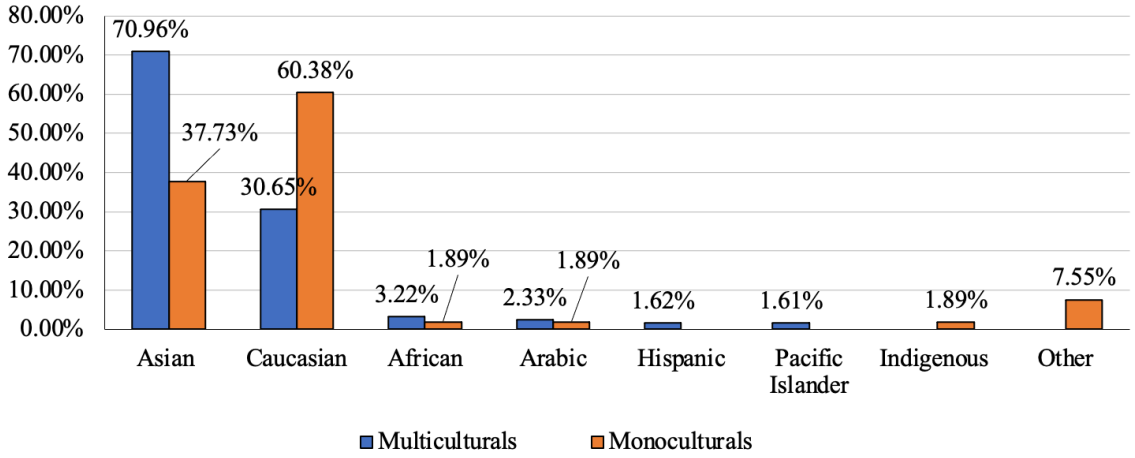


Note. This figure represents the most common languages spoken by participant group.

Ethnicity. Asian (multi = 70.96%, mono = 37.73%) and Caucasian (multi = 30.65%, mono = 60.38%) were the most commonly reported ethnicities (see Figure 9).

Figure 9

Most Common Participant Ethnicities

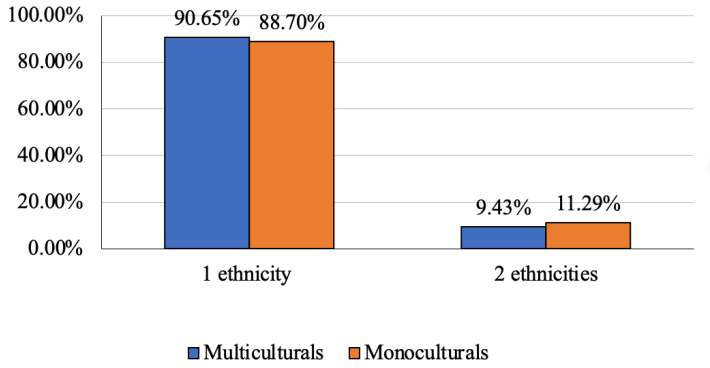


Note. This figure represents the ethnicity of our sample populations divided by participant group.

Ethnic Diversity. Multicultural's and monocultural's report similar ethnic diversity (i.e., number of ethnicities identified); 11.29% of monocultural's identified as possessing two ethnicities compared to 9.43% of multicultural's (see Figure 8).

Figure 10

Ethnic Identity Diversity of Participants



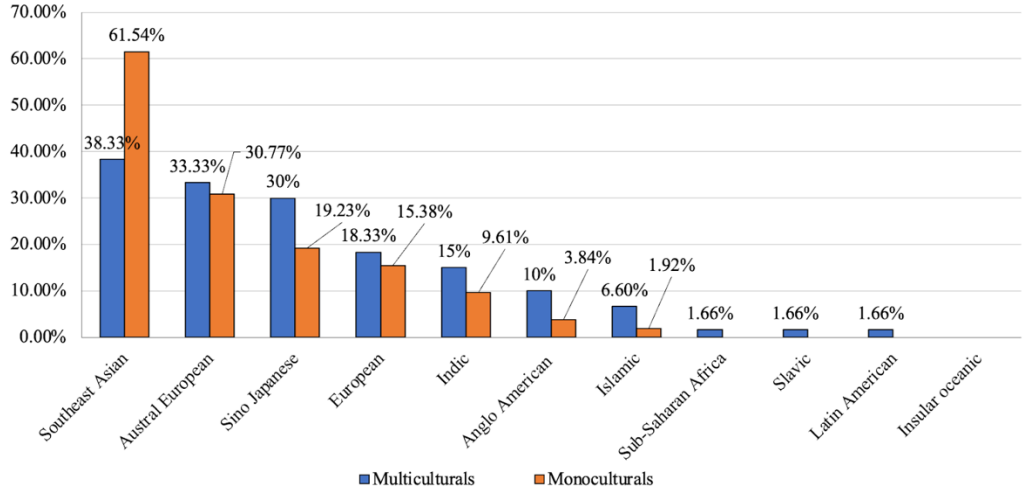
Note. This figure represents the number of ethnicities each participant group reported.

Cultural Identity. The most commonly reported cultural identity was Southeast Asian (38.33%) for multicultural's and Austral European (61.54%) for monocultural's. The second most

commonly reported cultural identity was Austral European (33.33%) for multicultural's and European (30.77%) for monocultural's (see Figure 10).

Figure 11

Most Common Cultural Identities of Participants

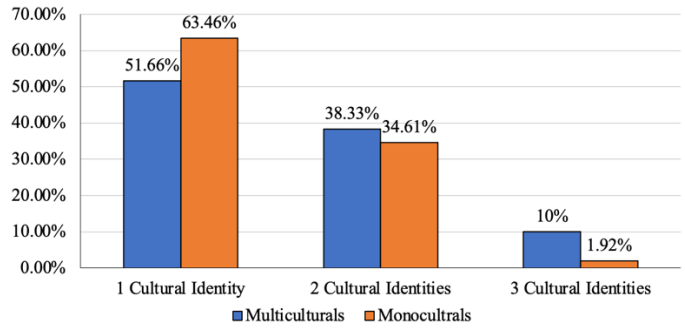


Note. This figure represents the cultural identities listed by each participant group.

Cultural Identity Diversity. Multicultural's report greater cultural identity diversity: half identify with one cultural identity (51.66%), and the other half either identify with two (38.33%) or three (10%) cultural identities. Amongst monocultural's 63.46% identify with one cultural identity, while 34.61% identify with two identities and 1.92% identify with three identities (see Figure 11).

Figure 11

Cultural Identity Diversity of Participants



Note. This figure represents the number of different cultural identities each participant group listed

6.9. Appendix I

Divergent Association Task Scoring Rules

1) Use only single words. We used this rule because computational methods can score single words with less ambiguity than phrases. Words such as “cul de sac” were accepted and automatically hyphenated.

2) Use only nouns (e.g., things, objects, concepts). This rule keeps the class of words similar since the distance between words varies based on their part of speech, such as whether they are nouns or adjectives.

3) Avoid proper nouns (e.g., no specific people or places).

4) Avoid specialized vocabulary (e.g., no technical terms). This rule and the previous one prevent participants from using words that are too specific, which is one strategy to artificially inflate the score. To enforce these rules, only lowercase words from a common dictionary (53) were used in the calculation.

6.10 Appendix J

9 July 2020

Ethics Approval Letter

Dr Margaret Webb
Melbourne School of Psychological Sciences
The University of Melbourne

Dear Dr Webb,

I am pleased to advise that the Psychological Sciences Human Ethics Advisory Group has approved the following Minimal Risk Ethics Application

Project title:	**Differences in Cognitive Processing in Multi-Cultural Individuals**
Ethics ID:	**1955321.3**
Other Researchers:	**Miss Pascale Bockelmann, Mr Thomas Djossou, Dr Andrew Ryder, Assoc. Prof Samuel Veissiere, Mr Sujai Thomman**
Approval period:	**09-Jul-2020 to 31-Dec-2020.**

Psychological Sciences HEAG has reviewed and approved amendment to this Minimal Risk ethics application 1955321.3 In line with government directives on social distancing during the COVID-19 pandemic, research activity that involves researchers being physically present for data collection with human participants (such as faceto-face field work, experimental and cohort studies, clinical trials etc) cannot currently commence and will need to be deferred and rescheduled. In exceptional circumstances, where such activities are part of priority research, including that directly related to the University's COVID-19 response, approval to commence may be given by the relevant Dean and endorsed by the Deputy Vice-Chancellor Research.

Desk-based elements of your research project can commence now, as can data collection that can be conducted online or via telephone, subject to necessary approvals or amendments to ethics applications.

Researchers will be advised by the University when other elements of planned and approved data collection can commence. Please consult the COVID-19 website for research guidance, FAQ and updates. https://staff.unimelb.edu.au/covid-19-response/research-activity.

It is your responsibility to ensure that all people associated with the Project are made aware of what has actually been approved.

Research projects are normally approved to 31 December of the year of approval. Projects may be renewed yearly for up to a total of five years upon receipt of a satisfactory annual report. If a project is to continue beyond five years a new application will normally need to be submitted.

On behalf of the Ethics Committee I wish you well in your research.

Yours sincerely

Dr Patrick Goodbourn
Chair of Psychological Sciences Human Ethics Advisory Group

Melbourne School of Psychological Sciences
The University of Melbourne, Victoria 3010 Australia
T: +61 3 8344 6377 **F:** +61 3 9347 6618 **E:** enquiries@psych.unimelb.edu.au
W: http://psychologicalsciences.unimelb.edu.au/

V Chapter: Comprehensive Discussion - Ongoing Questions and Implications for Further Research

In these two manuscripts we sought to explore the cognitive dimensions of exposure to diverse cultural environments. We were interested in determining whether the advantages in creativity and flexible problem solving hypothesized to be exhibited by multiculturals could be captured with the *cognitive flexibility* construct. We sought to investigate this topic with a systematic literature review study to determine how the CF construct is currently conceptualized and assessed. We also aimed to empirically measure the effect of diverse cultural experiences during key developmental periods on higher and lower order cognitive flexibility functions. We hoped to provide empirical evidence to support the theory that cognitive flexibility advantages emerge through the repeated inconsistency-resolution multicultural environments require. This contrasts with theories that the language switching present in bilingualism, which often overlaps with biculturalism, enhances CF. Despite limitations, our empirical study results suggest that CF is a cognitive process strengthened during diversity-exposure. In this comprehensive discussion, we aim to explore the relationship more broadly between culture and CF to address the ongoing questions still present after conducting our two studies. First, we address some of the limitations and challenges pertaining to the measurement of both CF and multicultural constructs. Second, we consider the socio-cultural factors which contribute to a diversity in multicultural experiences and can differentially influence CF development. Third, we discuss the psychological impacts these diverse multicultural experiences can have and the role of CF in mediating these psychological outcomes. Overall, through this comprehensive review we hope to elucidate some of the implications our study findings could have across research disciplines.

5.1. Measurement

In both our systematic review and empirical study, we faced considerable challenges in the measurement of the CF and multicultural construct.

5.1.1. Cognitive Flexibility Measurements

Our systematic literature review revealed numerous flaws in the current conceptualizations and measurements of the CF construct. Most notably, our results suggest that none of the tasks currently used to assess CF are purposefully designed to measure CF. Instead, most measures used for CF are borrowed from research areas on broader cognitive domains such as executive functioning. In addition, we did not find that the CF tasks used to assess cultural populations possessed unique features when compared to CF tasks used in non-cultural contexts. Our empirical study's literature review revealed that task-switching paradigms are most frequently used to assess CF in cultural contexts. This measurement choice is problematic when attempting to assess cognitive advantages in multicultural populations. Task-switching paradigms are ill suited because they capture lower order CF when multicultural experiences tend to strengthen higher order CF. As a result, many CF studies fail to appropriately assess and report CF capacity in multicultural individuals. The lack of CF measurement specificity (i.e., measures designed specifically for the CF construct), as well as measurement sensitivity (i.e., measures designed with sensitivity to the effects of cultural context) speak to the underdevelopment of the CF field. Overall, these measurement difficulties demonstrate some of the challenges in dealing with a construct as complex and multifaceted as CF. Consequently, the *meta-competency* framework our systematic literature review proposes aims to alleviate these measurement challenges and allow previous research work to be consolidated.

5.1.2. Multiculturalism Measures

Our literature reviews also revealed that due to the *multicultural* construct being fluid and dynamic in nature, there have been significant issues regarding its measurement (Rasmussen & Lavish, 2014). While the term *multicultural* is typically taken to be comprised of both ethnic and cultural diversity, there are large variations in researcher's interpretations depending on their disciplinary leanings (Reitz, 2009). As such, much of the diversity that exists in the measurement of the *multicultural*

construct is due to the term being defined by researchers in diverse ways (Benet-Martínez & Haritatos, 2005; Berry, 1997; Schwartz & Zamboanga, 2008). Firstly, due to many researchers' focus on operationalizing *multicultural* through demographic group labels, (i.e., diplomat, international school student, immigrant), measurement is often overly simplified. This operationalization often excludes empirical definitions for multiculturalism (i.e., length of cultural exposure, degree of cultural distance between exposure cultures, etc.) (Sedlacek & Kim, 1995). Secondly, some researchers only characterize individuals as *multicultural* when they belong to 'non-dominant ethnic groupings' (Surak, 2017). Through this ethnic minority lens these researchers tightly tie the *multicultural* construct to specific ethnicities and acculturation experiences. Consequently, researchers with this definition of *multicultural* often use acculturation tasks (i.e., measures to assess how individuals choose to negotiate their identity relative to the majority culture). The problem with this approach and related *minority stress* (Testa et al., 2015) models, is that they do not clearly define the objective elements that constitute multicultural experiences in and of themselves. Instead, such approaches and models highlight how individuals psychologically cope with the social dominance of a particular ethnicity and culture over another. Thirdly, other researchers view multilingual ability as a proxy measure of the *multicultural* construct. However, this lens is problematic as evidence of multilingual capacity is not sufficient to assume individuals' exposure to culturally diverse experiences. Fourthly, some researchers believe belonging to multiple cultural communities without relocating is sufficient to deem an individual as *multicultural*. For instance, the children of immigrants are defined *multicultural* as even though they are born and raised in one country (Portes & Rumbaut, 2001, 2006 as seen in Schwartz & Unger, 2010). They also often include individuals who live in ethnic enclaves, where heritage culture is maintained across generations regardless of the majority culture (i.e., Hasidic Jews) (Huynh, Nguyen, & Benet-Martínez, in press, as seen in Schwartz & Unger, 2010). Lastly, as societies around the world are culturally diverse (Berry & Ward, 2016) some researchers define multiculturals as individuals who live in multicultural cities and interact with people from a plethora of cultural backgrounds. As a result, given all of these socio-cultural and psychological dynamics present in bicultural individuals, Chao and Hong (2007), state that biculturalism should be investigated from a multilevel and multidimensional perspective. However,

although some attempts have been made to measure the multicultural construct, none were suitable for our study. Consequently, we ended up creating our own definition and measure which quantifies multiple dimensions of the multicultural experience including cultural identity, ethnicity, language, and birthplace. As a result, the measure designed for our empirical study is, to our knowledge, currently the most comprehensive measure available for the multicultural construct.

In conclusion, the complexity and lack of development of measures for the CF and multicultural constructs seem to have posed a significant obstacle in the past for research on CF and multiculturalism. However, through our new CF meta competency framework as well as our new empirically grounded and comprehensive multiculturalism measure, we hope to have improved the research field. Specifically, we hope to increase the understanding amongst researchers of the holistic nature of both constructs and facilitate discoveries on the relationship between multicultural exposure and CF capacity.

5.2. Psycho-Social Dimension

Multicultural exposure can entail vastly divergent psycho-social experiences that may drastically affect individuals' capacity to develop CF. In this section we review three main components of psycho-social experiences which affect multiculturals: acculturative stress, cultural integration and racial discrimination.

5.2.1. Limitations

Acculturative Stress. One limitation of our empirical study's multiculturalism measure is that it did not account for divergent socio-cultural experiences and the acculturative stress they may bring. Both of these variables may mediate the ability for multicultural experiences to positively impact CF development. For instance, our multicultural study participants may have been immigrants, refugees, sojourners (e.g., international students, expatriates), indigenous people, ethnic minorities, and mixed-ethnic individuals (Berry, 2003; Padilla, 1994 as seen in Nguyen & Benet-Martínez 2007). Each of these groups have vastly different levels of acculturative stress (i.e., reduced well-being due to assimilation

with a dominant culture) depending largely on whether they were *voluntary* or *involuntary* migrants. Ogbu and Simons (1998) defined voluntary migrants as those who chose to move countries, (i.e., immigrants, sojourners etc.), while involuntary migrants were defined as individuals who had joined the majority society against their will (i.e., the conquered, and colonized). Each of these migrant histories have different levels of acculturative stress. This is an important variable to consider in CF research as increased cortisol has been found to correlate with worse performance on task switching measure (Goldfarb et al., 2017). Consequently, high acculturative stress may impact performance on certain CF measures. Our empirical study not accounting for differences in socio-cultural experiences, and consequently acculturative stress, may have contributed to the lack of significance of our study findings. Instead, we incorrectly assumed a level of homogeneity in our multicultural sample's psycho-social background. Future studies should distinguish between individuals with voluntary versus involuntary multicultural experiences as include a measure for acculturative stress. This would allow researcher to account for the effect of minority stress (Testa et al., 2015) on CF performance. Overall, controlling for these two variables would allow researchers to better determine which components of multicultural experiences benefit versus hinder CF development.

Cultural Integration. In the same vein, another limitation of our empirical study was not accounting for participants level of *cultural integration* which has been shown to impact CF. Cultural integration, or the degree to which individuals have adapted to different cultures, was found to mediate the relationship between living abroad and creativity (i.e., higher order CF) (Maddux & Galinsky, 2009). Benet-Martínez et al., (2002) created the Bicultural Identity Integration (BII) framework which is the lens most commonly used to understand cultural integration (Yeung & Bellehumeur, 2021) and focuses on the compatibility of cultures values. Bicultural's who view their cultural identities as conflicting think more complexly about their cultures and tend to have lower levels of cultural integration (Chen & Padilla, 2019) and greater acculturative stress (Bae, 2019). Biculturals' who view their cultural identities as compatible, engage equally with both cultures and therefore have a higher levels of cultural integration (Benet-Martínez and Haritatos, 2005; Saad et al., 2013) and less acculturative stress.

Integrated individuals tend to have higher CF and are more likely to experience the beneficial outcomes of multicultural life (Dovidio, Gaertner, & Saguy, 2009; Verkuyten, 2005 as seen in Gocłowska & Crisp, 2014). A study found that compared to individuals with low cultural integration, individuals with integrated identities showed more flexibility, fluence and novelty on a creative uses task (i.e., higher order CF) (Tadmor et al., 2012). Another study found immigrant children with integrated identities (i.e., who identify equally with their ethnic heritage and host-nation cultures) to perform better on switching tasks (i.e., lower order CF) than peers who prefer one culture over another (Spiegler & Leyendecker, 2017). In conclusion, individuals with integrated cultural identities may have a greater ability to reap the benefits of CF development multicultural exposure can confer. Not considering identity integration as a variable in our research may have affected our study findings. Consequently, future research should include a measure on cultural identity integration to control for individual participant differences and determine the predictive validity of BII level for CF capacity.

Cultural Traits. Another limitation of our empirical study was not taking into account the potential cognitive advantages some participants may have due to the values their cultures instill. Certain cultures tend to confer specific values or traits that can propel individuals to achieve greater success after relocating to a new country. Chua and Rubenfeld (2014) pioneered the concept of the *triple package*, a bundle of three traits (i.e., narratives of superiority, a feeling of "never-good-enough" insecurity, and impulse control) which together confer advantages for adapting and succeeding in multicultural societies. Of the three traits, impulse control (i.e., the habit of discipline), may be the cultural trait which may most significantly contribute to CF capacity. Individuals with impulse control are defined by their ability to 'systematically sacrifice present gratification in pursuit of future attainment' (Chua & Rubenfeld, 2014). This cognitive trait has been linked to the ability to develop greater cognitive control and self-regulation; an important aspect of lower order CF. Impulse control has also been shown to lead to greater resilience and ability to endure hardship. As such, future research on CF and culture should consider individual's dominant cultural background to control for culturally based CF advantages. Overall, it is likely that *multiculturalism* itself may be the "fourth" trait that helps confer such high economic and educational success rates in many immigrant groups such as Cubans, Iranians, Jews, Igob

Nigerians, etc. Indeed, growing up learning the codes of one's home culture in addition to that of the host country provides one with a unique opportunity for perspectivist flexibility

5.2.2. Implications

Racial Bias and Social Flexibility. Our work connecting CF to multicultural experiences may have significant implications for research on the reduction of implicit racial biases. One study's findings suggested that bilingual children demonstrate reduced social bias relative to their monolingual peers (Singh et al., 2021). Biculturalism has also been associated with reduced racial bias. Another study suggests bilinguals to report higher social flexibility than monolinguals: '(a) switch with ease and adapt between different social environments and (b) accurately read social cues in the environment' (Ikizer et al., 2018). These findings may be due to biculturals having a heightened ability to monitor, detect and inhibit the activation of stereotypical assumptions due to higher frequencies of inconsistency resolution. In addition to their increased inhibition of stereotypical bias, these findings may also be due to multiculturals being less prone to essentialist beliefs. In other words, they are more aware that one individual can belong to many different social and cultural categories. Phillips (2010) defined essentialism as 'the attribution of certain set of unwavering characteristics to everyone subsumed within a particular category'. Lastly, these findings may be due to multiculturals having a deeper appreciation for multicultural complexity. In other words, they are less likely to accept quick and easy, but wrong answers by imposing their cultural perspective on others (Pedersen, 2006). Future research on racism may benefit from investigating the ability for mental training in CF skills to increase social flexibility and decrease racial bias. Similarly, political philosophy on anti-essentialism may benefit from investigating the effect of multiculturalism on more open and flexible political ideologies.

5.3. Psychological Dimension

CF is an important area of research because of the prominence of psychological flexibility in understanding psychological health (Kashdan & Rottenberg, 2010). This is because in many forms of psychopathology CF is impaired, while in those with resilience CF is heightened.

5.3.1. Limitations

Personality Traits. One limitation in our empirical study may be that we did not account for certain innate (i.e., dispositional) psychological traits influencing individual's tendency to develop CF. Certain individuals who are high in experience-seeking may be innately predisposed to acquiring heightened CF due to psychological tendencies to cognitively and socially explore their environments. Firstly, greater exploration behaviour has been found in individuals with higher resilience and positive self-perceptions because of reduced failure and social rejection concerns (Zeigler-Hill et al., 2015 as seen in Chen & Padilla, 2019). Burnam and colleagues (1987) also found individuals with a stronger sense of self (i.e., ambitious and capable) may be better equipped to cope with the *acculturative stress* of multicultural experiences. In addition, individuals who have a greater level of comfort with ambiguity and uncertainty may be more predisposed to strengthening their CF capacity. In a study on Need for Closure and CF, which compared autism spectrum disorder and typical development individuals, it was found that worse CF positively correlated with an increased preference for predictability and close-mindedness (Fujino et al., 2019). In contrast, divergent thinking scores were negatively correlated with Need for Closure, and positively with Openness to New Experiences (Celik et al., 2015). As such, several underlying psychological traits (i.e., cognitive exploration, resilience, need for closure) may cause individuals to self-select for environments and experiences that improve their CF. In conclusion, although multicultural exposure may be an important variable influencing CF development, psychological traits may drive individuals' decisions to relocate to new places, engage with different cultures, and adapt in healthy ways. Future research should include personality measures to determine the relationship between multiculturalism, CF strengthening and personality traits.

Psychological Effects of Cultural Integration. Furthermore, psychological traits may also influence which type of cultural integration strategy individuals select. Cultural integration in turn has been shown to have huge impacts for psychological health. Research has shown Bicultural Identity Integration differences may be predictive of psychological adjustment (after controlling for neuroticism and self-efficacy) (Benet-Martínez, Leu, Lee, & Morris, 2002 as seen in Chen et al., 2008). Greater BII has been associated with less severe diagnostic labels (as seen in LaFromboise, et al., 1993). In contrast, lower BII has been associated with increased lifetime rates of phobia, alcohol and drug abuse or dependence (Burnam et al., 1987). In Cuellar, Harris and Naron's (1981) study on Mexican American psychiatric patients, it was found that BII level negatively correlated with both psychiatric diagnosis and treatment outcomes, i.e., lower BII was associated with worse outcomes. One study found bicultural individuals tended to score higher on perceived health and well-being measures when they had both highly independent and interdependent self-construal compared to biculturals with marginal self-construal (Yamaguchi, 2016). These outcomes may be linked to CF capacity, since BII levels and CF are associated and reductions in CF is one of the mechanisms through which mental disorder risk has been shown to increase (Goschike, 2014). As a result, CF may be a key variable mediating both multiculturals' psychological adaptation to new cultural environments as well as their psychological well-being. Further research is needed to investigate the exact relationship between these three variables. Overall, bicultural individuals' higher cognitive complexity relative to monoculturals can lead to psychological difficulties which need to be accounted for in empirical studies (Chen & Padilla, 2019). Consequently, a limitation of our empirical study was not including a measure for psychological health as this is known to affect cognitive performance independent of cultural integration and CF.

5.3.2. Implications

Clinical Research. Our research may have important implications for cross-cultural psychiatric research on the risk and protective factors of mental disorders in multicultural populations. Knowledge on this subject could improve clinical psychologists' 'understanding of how symptoms, syndromes and psychopathology emerge' (Kirmayer, 2019) in multicultural population to begin with. Certain

multicultural populations have been known to suffer from increased rates of psychiatric conditions. Immigrants have been found to have higher rates of psychosis (Kirmayer, 2019). Greater risks for schizophrenia were found in first-generation and second-generation migrants due to chronic social adversity and *social defeat* experiences (Selten et al., 2007). Williams and Berry (1991) claimed that biculturals were more likely to experience 'anxiety, depression, feelings of alienation, heightened psychosomatic symptoms and identity confusion'. After controlling for ethnicity, socioeconomic status, gender, and age, bicultural stress was found to be significantly positively associated with depressive symptoms (Romero et al., 2007), suicidal ideation (Piña-Watson et al., 2015), and high-risk behaviors such as smoking, drinking, drug use, and violence (Romero et al., Nov 2007). However, there is also evidence that multicultural experiences protect individuals against psychiatric conditions. One study found Mexican immigrants mental health prevalence to be 50% less than those of Mexican descent born in the United States (Escobar, 1998). Another study by Sirikantraporn (2013) found that bicultural youth were more likely to be resilient after witnessing domestic violence than monocultural youth. Consequently, the relationship between CF functionality in multicultural populations and psychiatric disorders may be an important link to explore. Particularly to establish which aspects of exposure to multiple cultures (e.g., CF or other) function as psychologically protective factors. For instance, research on the role CF strengthening to improve individual's capacity to cope with trauma would be highly valuable for PTSD researchers.

Conflict Resolution. Knowledge of the basis of multiculturals unique skill set is also highly relevant for research on conflict resolution. Due to the techniques multicultural individuals employ 'to negotiate and resolve cultural differences within themselves and with others, they may be applied to negotiate and resolve cultural differences across individuals and groups of individuals' (Nguyen & Benet-Martínez, 2007). This may be because multiculturals have access to a wider array of knowledge on culturally different approaches to conflict resolution (Pedersen, 2006). Consequently, CF strengthening mechanisms may be of interest to family counselors and therapists who are looking to develop activities and intervention techniques to counteract cultural biases and improve treatment outcomes (Zaker & Boostanipoor, 2016). Multiculturals experience with multiple cultural perspectives

may increase their awareness of how conflicts are grounded in a joint meaning-construction process. As a result, the number of practical and theoretical options they see available for conflict resolution are more abundant (Pedersen, 2001, 2005 as seen in Pedersen, 2006).

Leadership. The cognitive qualities that may give multiculturals a superior ability to be valuable and compelling leaders is highly relevant for research on international businesses and corporations. Research has shown leaders with more than one cultural profile to have enhanced cross-cultural leadership effectiveness due to superior emotional and cognitive competence (Lakshman, 2013). These leadership advantages align with other research which found individuals who have lived abroad to achieve greater creative and professional success (Tadmor et al., 2012). Specifically, they found highly integrated bicultural professionals to produce more innovations at work, achieve higher promotions rates, and build more positive reputations than assimilated or separated individuals (i.e., low levels of cultural integration) (Tadmor et al., 2012). Some have hypothesized this enhanced leadership success to originate from multicultural individual's excellent information processing capacity which allows them to consider and combine multiple perspectives (i.e., higher order CF) (Tadmor et al., 2012). Others have linked these leadership advantages to bicultural individuals' higher *attributional complexity* and *attributional knowledge* (Lakshman, 2013). *Attributional complexity* describes 'the degree to which an individual is interested in understanding the causes of other's behaviors and considers different possible causes' (Fletcher et al., 1986). And *attributional knowledge* refers to an individual's knowledge of different cultures which helps them to read social situations more accurately and in less culturally biased way (Lakshman, 2013). Overall, multiculturals' leadership capacity may be enhanced because of their higher CF.

5.4. Conclusion

In sum, individual differences in the ability to cognitively engage with the process of cultural integration may significantly influence the opportunity to develop higher CF and therefore reap its associated benefits (Spiegler & Leyendecker, 2017). Specifically, the ability to devote the cognitive resources to inconsistency resolution is influenced by numerous socio-cultural factors (e.g., racial

discrimination, minority group status, etc.) as well as psychological factors (e.g., personality traits, psychological health, etc.). Variations in these factors significantly influence whether individuals find cultural integration bothersome and stressful or whether they are intrigued and challenged (Spiegler & Leyendecker, 2017). Consequently, different types of multicultural experiences and ways of relating to these multicultural experiences influence CF development in vastly different ways. In particular, the social and psychological challenges of relocation pose a great risk threat to the development of these cognitive and psychological advantages across intra- and inter- personal domains. Not considering these socio-cultural and psychological factors in our study caused us to assume an incorrect level of homogeneity within our multicultural sample that likely influenced the accuracy of our results. Our research tells a story of the specialized cognitive training ground multicultural environments can provide and the great potential that exists for multiculturals to excel across several spheres of life through their unique skill set. And with this knowledge of the potential multicultural experiences have to positively affect individuals, we wish to encourage "institutions and policies in all fields to treat diversity as a potential resource and a public good that needs to be distributed, and not as a nuisance to be contained" (Zapata-Barrero, p.12 as seen in Kirmayer, 2019). Our work has implications for other research domains centering on racial bias reduction, therapeutic interventions, conflict resolution and leadership. Overall, we hope to have provided insight into how diverse cultural environment exposure can differentially impact CF and therefore dramatically shape social and psychological outcomes.

However, with all the risks associated with multiculturalism, one last question remains – is multiculturalism worth it?

VI Chapter: Conclusions

Although multiculturalism is seeing as a deficit by many, there is an increased body of evidence showing advantages at the level of psychological flexibility and resilience to exist for some individuals. Cultural psychologist Andrew Ryder speculates that this may be due to multicultural experiences being a "genuinely fraught complex experience, with high risks and high rewards" (A. Ryder, personal communication, January 15th, 2020). In other words, though there are hugely beneficial cognitive and psychological advantages which may be garnered through multicultural experiences, there are equally great risks of suffering from poor socio-cultural adaptation, maladaptive coping, and psychiatric conditions. Thus, the high-risk high-reward ratio of multicultural lifestyles begs the question: are the potential risks and hardships associated with multicultural experiences the reward? consequently psychological dis-ease.

The risks of multicultural experiences, from an evolutionary and cultural psychology perspective, mainly center on multicultural individuals being *a people without a tribe*. Consequently, multiculturals may lack a fundamental sense of psychological physical safety because they do not belong to a stable community. This absence of a community may lead to identity confusion because multiculturals learn not one, but many, cultural meaning systems. In addition, this shortage of a stable community, may also lead to a lack of a coherent life narrative. Learning to see the world through many cultural lenses rather than just one, may take a toll psychologically because it requires a significant amount of energy to continuously encounter new perspectives and incorporate events into an existing world view. Furthermore, multiculturalism means being an outsider; continuously trying to learn what the correct customs are in a culture. In addition, multiculturals need to live with being fundamentally different from others because rather than relating to strongly to one culture, they relate to many, which gives them a unique perspective. Ultimately, multiculturalism is a vulnerable position to occupy socially and psychologically because it means living with a high degree of ambiguity - in a state of not knowing.

In contrast, multiculturals being removed from a distinct set of socio-cultural rules may also confer numerous benefits because they are able to view society from a super ordinate level. Firstly, they

are less likely to think in essentialist ways, for example, hold strong nationalistic beliefs or make prejudiced assumptions about others. This allows multiculturals to be more aware of the similarities people share and consequently act as a bridge between people from different backgrounds. Secondly, through their diverse cultural exposure multiculturals are more likely become aware of their own biases and therefore gain increased self-awareness and act with greater conscientiousness about which beliefs they chose to accept and reject as truth. Thirdly, by learning how a culture's values and beliefs shape the prioritization of goals and perceptions, multiculturals may draw from and tap into each cultures' strengths.

Both these high risks and high rewards reveal that the key to being successful and leading a multicultural lifestyle is comfort with a greater degree of change, uncertainty, and ambiguity. Predominately individuals can learn to reap the rewards of multicultural environments if they can live with having an identity centered on malleability, rather than stability. This is a challenging identity to master because it requires individuals to experience themselves through a multiplicity of cultural lenses instead of maintaining a core *sense of self.* This is exactly where the risk and the reward of multiculturalism lies: in living with the acute awareness of the flexibility of the mind and the subjective nature of human experience.

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