Cultural Evolutionary Psychology as Generalization by Recursion[*]

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Abstract

[3] Cultural evolutionary psychology (CEP) accounts for the cultural evolution of cognition. It is based on evolutionary psychology and cultural evolutionary theory and aims at a synthetic attempt which is achieved by what we want to call "generalization by recursion". We argue in this paper that the evolutionary psychology program as a whole could greatly benefit from CEP's generalization. As we will show, there is one theoretical element in particular, that CEP relevantly generalizes in contrast to its predecessors. It comes from cultural evolutionary theory and has been referred to as the "dual inheritance argument". CEP's novelty consists in showing that not only cognitive products ('grist') but also cognitive mechanisms ('mills') are subject to cultural evolution and provides lots of empirical evidence for this claim. This account is 'recursive', because CEP's generalization of the dual inheritance argument theoretically employs a recursive feedback-loop between cultural learning and cultural evolution. We also argue that this account might be considered to supersede unificatory and reductionistic efforts of its competitors, because it is stronger than purely structural or analogical unification while at the same time it is not too strong in order to fall prey to implausible reductionism.

Kewords. *cultural evolution*, *evolutionary psychology*, *dual inheritance theory*, *theoretical generalization*

List of Abbreviations:

EP	Evolutionary Psychology
CEP	Cultural Evolutionary Psychology

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CET Cultural Evolutionary Theory (Campbell Style)
DIT Dual Inheritance Theory ('California School') [4]

1 Introduction

'Cultural evolutionary psychology' (CEP), also known as 'cognitive gadgets theory' (Heyes 2018a) stands on two theoretical pillars: classical evolutionary psychology (EP) and cultural evolutionary theory (CET). Heyes was influenced by both within the context of formulating CEP because the main postulate of CEP concerns the cultural evolution of cognitive mechanisms.

Particularly the latter claim brings in an innovative component of CEP that has significant impact in covering a diverse set of evidence from cognitive science. In this paper, we want to reconstruct the relevant components CEP builds on, show how it innovatively generalizes them, and outline that the feature of covering a diverse set of evidence makes CEP a promising candidate to allow for better explanations in the field of the evolution of cognition. In particular, we want to argue that CEP's unifying generalization takes in a promising middle ground between purely structural or analogical unification as suggested by some branches of CET and too strict reductionist aspirations that are sometimes ascribed to EP.

In section 2, we outline the program of CEP, its historical relation to EP and classical, Campbell style, CET. We will see that, whereas EP has a tendency to formulate a program too strong and too reductionistic in spirit to be upheld within the field of the evolution of cognition, CEP – with its core assumption of cognitive mechanisms being not instincts but gadgets that are acquired by cultural learning – is more modest. Nevertheless, it is able to put forward a generalization.

For the purpose of empirical grounding of our theoretical discussion of section 2, section 3 aims at showing that CEP is capable of explaining a diverse range of evidence from cognitive science. We will do so by outlining how CEP aligns with current evidence regarding two cognitive mechanisms that are of particular importance for *cultural learning*, namely imitation and mind-reading.

Finally, in section 4, we discuss two possible objections to CEP's generalization. First, the problem that CEP's reliance on a selectionist version of CET asks for clarifying what the units of selection are; we argue that this difficult problem might be no disadvantage but rather a feature of CEP, since CEP generates new hypotheses suggesting new forms of experiments by help of which this question could be addressed. Second, the problem that dual inheritance theory of the 'California School' (DIT) might make CEP superfluous, because it provides already a generalized approach of the field of the evolution of culture. However, although we think that DIT indeed provides some generalization in terms of using a general (mathematical) framework, we argue that CEP exceeds the structural boundaries by not only encompassing, but also (recursively) linking evidence concerning cognitive mechanisms and cognitive products.

2 From classical EP to CEP's Recursive Generalization

In this section, we will illuminate the core assumptions of EP and CET, as well as the generalizing effort of CEP. Before we get into the theories under consideration, let us first characterize in brief what we mean with 'generalization' and how it relates to other forms of connecting theories and evidence. [5]

Baraghith and Feldbacher-Escamilla (2021) distinguish four forms of connecting theories and evidence of several fields of (cultural) evolution: metaphor, analogy, generalization, and reduction. For the purpose of our discussion, we can bypass metaphorical linking. Rather, we outline the relevant distinction between analogical, generalizing, and reductionistic approaches. Analogical accounts operate on the assumption of structural similarities between two domains. So, e.g., Dawkins (1976) gene-meme analogy is supposed to carry over principles of natural evolution concerning principles acting on gene replicators to the cultural domain by speaking of partly structurally similar principles acting on meme replicators. Relevant for us is the focus on *structural similarities*, something that (Morrisson 2000, p. 2) has also highlighted in her discussion of unification. Morrisson subsumes approaches based on structural similarities under the unification paradigm. Deviating from Baraghith and Feldbacher-Escamilla (2021), we follow her in this here and consider purely structural/analogical as well as generalizing and reductive approaches as unifying.

Next, let us come to generalizations. They play an important role in science and scientific methodology. The most straightforward form of generalization consists in expanding the domain of a hypothesis or theory (e.g., generalizing a hypothesis about the expansion of iron when heated to a hypothesis about such an expansion of all metals in general). Such generalizations are based on inductive inferences. However, oftentimes generalizations are not only about the domain, but also about the theoretical structure of a hypothesis or theory (e.g., when Darwinism was generalized or when relativity theory was generalized). In such a case, it is not only inductive reasoning that plays an important role, but also abductive reasoning, see Schurz (2008) and Feldbacher-Escamilla and Gebharter (2019). Such reasoning is *selective*, when it is about theory choice and the question of opting for the most general, simple, "lovely", and accurate hypothesis and theory, see e.g., inference to the best explanation as described in Lipton (2004). And it is *creative*, when it is about constructing a hypothesis or theory that best accounts for data and theoretical constraints, see e.g., common cause abduction as described in Schurz (2008). An important feature of generalizations in terms of creative abduction is that they square well with general theoretical constraints as discussed in the philosophy of science such as unification and simplicity, see Baraghith and Feldbacher-Escamilla (2021). It is also important to note that such generalizations need not stick to their inferential basis absolutely "loyal", i.e., deviations from the basis are possible, if other features are better achieved by such a deviation. This means in particu-

lar, that, e.g., a generalization of theories can relevantly deviate from the theories. An important distinction to analogical accounts is that generalizations are not simply based on structural similarities that allow for, e.g., the application of one and the same mathematical framework in different domains but that the domains are linked by overarching laws and principles. Referring to (Morrisson 2000, p. 2), one can say that a "feature [of a unifying theory is that it] encompasses phenomena from different domains under the umbrella of a single overarching theory. Theories that do this are typically thought to have 'unifying power'; they unify, (i) under a single framework, (ii) laws, phenomena or classes of facts originally thought to be theoretically independent of one another." If we understand "single framework" here as a mathematical framework (such as models of population genetics), then her (i) amounts to what we call here "analogical approaches" and (ii) to what we call a "generalization" here.

Finally, let us have a quick view on reductive approaches. Basically, there are two forms of reduction. Given two theories or sets of hypotheses, with their respective bodies of evidence, one possibility consists in directly subordinating both bodies of evidence under one theory or hypothesis and simply disregard the other theory or hypothesis. [6] This form of reduction is *eliminative* with respect to the disregarded hypothesis or theory and is often carried out when it was supposed to be superseded by a better theory or hypothesis (as was historically the case with the kinetic theory of heat that superseded both phlogiston theory as well as the caloric theory of heat). Another possibility consists in incorporating one theory or set of hypotheses into the other. In a Nagelian reduction, such a subordination is achieved by the help of analytical principles, so-called 'bridge principles' or 'coordinating definitions', see Dizadji-Bahmani, Frigg, and Hartmann (2010). This form of reduction is advantageous if the subordinated theory or set of hypotheses was successful in explaining the respective body of evidence, because incorporating it allows one to also explain the success of it. In this way, e.g., the theory of thermodynamics was embedded into the theory of statistical mechanics (ibid.: 398). As we want to argue, whereas in the literature classical 'high church' evolutionary psychology (EP) is sometimes considered to have a tendency towards too strict eliminative reductionism and some forms of cultural evolutionary theory (variants of CET) are focusing on perhaps too loose structural similarities mainly (i.e. in our terminology on "analogies"), Heyes (2018a) provides an account to the evolution of cognition and culture that is based a generalization. As Heyes (2018a, p. 2) writes:

> "Cultural evolutionary psychology is like evolutionary psychology in having the human mind as its explanatory target, and like cultural evolutionary theory in emphasising the importance of social learning as a force in human evolution, but it differs from both of these approaches in suggesting that distinctively human cognitive mechanisms get their adaptive characteristics from cultural rather than genetic evolution."

We think that it is CEP's motivation to keep relevant theoretical elements from classical evolutionary psychology (EP) and leave others aside, while enriching it with new elements from cultural evolutionary theory (CET). In suggesting that distinctive human cognitive abilities, such as mindreading, imitation, complex causal understanding, teaching and many others are products of cultural rather than genetic evolution, CEP generalizes the term 'evolution' in a way, that makes its claims much more compatible with recent empirical data. Below, in section 2.3, we will discuss in which sense(es) CEP generalizes. For this purpose, it is important to sketch the components CEP builds on, namely the relevant core components of classical EP (see section 2.1) and that of CET (section 2.2). We will then discuss which elements CEP keeps and which it leaves aside, and what innovatively new elements it proposes.

2.1 Classical 'High Church' Evolutionary Psychology (EP)

There are many approaches to the study of mind and behavior that have been or could be called 'evolutionary psychology', see Downes (2018) or Shackleford and Weekes-Shackleford (2017). We focus here on 'High Church' EP see Tooby and Cosmides (1990, 1992), because it has been the most prominent and influential account.

According to this classical EP, we still have a 'Stone Age mind', which is nevertheless able to explain (products of) human culture. The picture is that humans may have sophisticated technology and social systems, but our minds (just as our genes) have not really changed for the past hundred thousand years. EP postulates that many human cognitive processes and their contribution to human culture can be satisfyingly explained by focusing on *ancestral* fitness consequences because our 'human nature' is fixed since the Pleistocene. EP is mainly constituted by the following three core assumptions: [7]

EP1 the massive modularity hypothesis of the mind,

EP2 the assumption that the modules are passed on genetically ('cognitive instinct hypothesis'),

EP3 the method of 'adaptive thinking'

According to (EP1), there are domain-specific psychological processes (given as computationally distinctive processes) that fulfil particular tasks in the mind, see Carruthers (2006). (EP2) claims that the genetically inherited mental modules are 'conserved', even though they might serve different purposes in recent time. (EP3) is closely connected to (EP2) and is put forward by proponents of EP as a method to identify adaptive problems that our early ancestors faced, see also Rellihan (2012). Selection pressures at that time caused the evolution of many different functionally independent psychological mechanisms, where each of these mental modules evolved to solve particular problems. The idea is that they reached fixation during the Pleistocene and are now universal to all members of the human species. Tooby and Cosmides (1992) are quite precise

in establishing adaptive thinking as a reliable method to identify and explain the functional components of current human minds and thereby also current human culture. The method consists of four steps, see Mameli (2009). An EP researcher should: 1) Try to determine the possible Pleistocene problem, 2) search for a psychological mechanism that would provide an optimal way to solve the problem, 3) posit the existence of such a mechanism in the mind of extant humans, and 4) gather evidence (e.g. in laboratory test situations or via observation of normal life situations) in order to confirm its existence in modern humans. As Buller (2005, p. 90) correctly indicates, the method of adaptive thinking in EP is a form of 'reverse engineering'.

To our understanding, adaptive thinking's major role for EP lies within the 'context of discovery', namely to provide some general schema for the introduction of new hypotheses. The other two principles of EP are relevant for the 'context of justification'. Many authors think that (this part of) EP is best described as a kind of scientific reduction, for details see Schickore and Steinle (2006), Buller (2005) or Barrett (2015). Dupré (2012, p. 72) describes EP as a hidden reductionism. In our terminology outlined above, such an interpretation of EP would even amount to a form of eliminative reduction, because the development of products of human culture is explained via the method of adaptive thinking without embedding respective sociological hypotheses.

Since it was formulated by Tooby and Cosmides (1990), EP has been criticized by many philosophers of biology, and for many different reasons. Sterelny (2003), for instance, questions the general reliability of 'adaptive thinking for mental modules'. Mameli (2009) points out that mechanisms of the human mind may finally not be (genetic) adaptations, as EP suggests. Similar arguments against EP *as* an adaptationist program can be found in Lloyd (1999), Richardson (2007), and most severely in Buller (2005). Smith (2020) critically notes that in order to fully justify EP's method of 'adaptive thinking', a contemporary cognitive trait would have to (i) have the same function as the ancient one, (ii) be related to it via direct descent, and (iii): both must have the same function because of (ii), see Smith (2020, p. 41). So, even if the architecture of modern and ancestral cognitive traits is similar (and this is far from evident), this would still not be enough to postulate evolutionary descent. She refers to this fact as the 'matching problem'. As a vivid example, she chooses the cognitive 'reading module' (Dehaene and Cohen 2011), which is too young – written language exists for roughly 4.000 years – for natural selection to act upon. [8]

2.2 Campbell's Cultural Evolutionary Theory (CET)

As we will see in a bit, CEP builds not only on EP but also on Donald Campbell's version of CET. Campbell used the term 'sociocultural evolution' long before dual inheritance theory (DIT) appeared in the scientific community, see, e.g., Campbell (1965) or Campbell (1974). One of his earliest and most influential papers applying Darwinian theory to human cultural evolution was 'Variation and Selective Retention in Sociocultural Systems', which appeared as a book-chapter in Barringer, Blanksten, and Mack (1965). Campbell style CET is

given by four core assumptions (Richerson and Boyd 2000):

CET1 Human sociocultural evolution should be studied using Darwinian methods. Like genes, sociocultural evolution (i.e. information transmitted via teaching and imitation) has a pattern of descent with modification.

CET2 Cultural and genetic evolution are linked (culture-gene coevolution).

CET3 The 'argument from natural origins': Natural selection remains the master force for cultural evolution. Natural selection is the ultimate source of the rules that proximally guide the evolution of culture.

CET4 The 'dual inheritance argument': selection on cultural variation can (in certain cases) also be as much an ultimate cause as selection on genetic variation.

(CET1) is the programmatic aim, it is Campbells' 'recommendation' for how the social sciences and psychology should study culture. Empirical cases of (CET2) are well studied, but rare. A vivid example for culture-gene coevolution is the positive causal correlation between lactose-tolerance (genetic) and milking habit (cultural), see Beja-Pereira et al. (2003). (CET3) comes already near to EP, since the 'argument from natural origins' claims that natural selection has shaped the *innate rules* that in turn shape cultural evolution, and that human psychology shows many signs of being shaped by natural selection. (CET4), the 'dual inheritance argument', tells a quite different story. It holds that cultural variants have a selective history that is decoupled from genetic fitness, and that we can even expect the spread of cultural variants, which *decrease* genetic fitness, at least in some cases. It is especially this argument, that later gave rise to the framework of DIT. It becomes obvious, that (CET3) and (CET4) of Campbell's original account stand to a certain extend in mutual tension, and Campbell worked a lot on solving this, at least, seemingly conflict between what has later been called 'evoked' versus 'transmitted culture', see Mameli (2009) or Gangestad, Haselton, and Buss (2006). While EP mostly focused on (CET3), DIT focused on (CET4). For developments in cultural evolutionary theory, this tension within Campell is remarkable, indeed. However, since Heyes (2018a) explicitly employs Campell's CET in her building of CEP, we will not delve into more detail regarding this problem here. Heyes (2018a) also most relevantly modifies the claims of CET, for which reason this problem plays no important role in her and our reasoning. Our reliance on CET as presented here rather than on a successor theory of cultural evolution is due to our aim of spelling out the basis of CEP that was in fact used. [9]

2.3 Cultural Evolutionary Psychology (CEP) as Recursive Generalization over Evolutionary Psychology (EP) and Cultural Evolutionary Theory (CET)

In sharp contrast to EP, CEP postulates that distinctive human cognitive mechanisms have been built and are transmitted by *cultural* rather than by genetic evolution, that they are 'cognitive gadgets' rather than 'cognitive instincts', see Heyes (2018a, p. 22). Like EP, drawing on the modularity debate in cognitive science, CEP suggests that specialized cognitive mechanisms are built by general-purpose mechanisms and that 'modules' are acquired, sensu Karmiloff-Smith (1995). Since its advent, CEP has been critically discussed against the background of a wide range of approaches and topics. While some researchers indeed see it as the long awaited "unifying effort" (McNamara and Neha 2019) to finally conciliate cultural evolutionary theory and evolutionary psychology, more critical authors see the theory as a "provocative but flawed manifesto" (Del Giudice 2019).

CEP is, however, more than a 'manifesto'. It achieves what we want to call a 'generalization by recursion'. In doing so it also 'blocks' the 'reductive' tendency of EP ('reductive' sensu Dupré (2012). We call Heyes (2018a) effort 'recursive' because of the feedback loop that cultural learning generates with cultural evolution, making both mechanisms ever more complex and sophisticated (see figure 2 for more details). The difference between social leaning in general and 'cultural learning' in particular is that the latter is a subset of the first. Cultural learning is "to isolate types of social learning that make the difference between the cumulative cultural inheritance found in humans, and the non-cumulative "culture" or "behavioral traditions" found in some other species." cf. Heyes (2018a, p. 84). Cultural learning is not entirely, but mostly exclusive to our species (see Gruber et al. 2022) for very interesting exceptions) and enables complex cognitive abilities such as mindreading, language, true imitation, teaching or complex causal understanding (ibid.). Furthermore, we call the effort of CEP in accordance with our terminological distinction above a 'generalization', because Heyes does not only aim at employing structural similarities, but in fact arrives at the core insights of CEP by generalizing the concept of 'dual inheritance evolution'. CEP assumes evolution to be more general than just gene-based biological evolution, and this generalized evolution is crucial to understand our cognitive architecture, given CEP, because our cognitive modules are now passed on via cultural evolution. By this, Heyes achieves an *overarching theory* that is based on such a generalization and a redistribution of the points of action of social learning. In what follows, we will present CEP's assumption in more detail.

Quite different from EP, CEP recognizes CET as a crucial explanatory part; a part that cannot be reduced to EP. Instead, including CET is the main difference between CEP and classical EP and by transcending both of its conceptual and theoretical ancestors, CEP provides more than just a conjunction of them. In total, CEP comes along with four synthetic and generalizing core assumptions:

CEP1 the modularity hypothesis of the mind

CEP2 the assumption that these modules are passed on *culturally* (cognitive gadgets hypothesis), via a robust second system of inheritance. This holds also for cognitive products, of course.

CEP3 the idea that genetic and cultural evolution can influence each other in positive or negative ways (culture-gene coevolution) [10]

CEP4 the assumption of 'cultural learning' as a *culturally* transmitted trait (except for the 'starter kits' contribution).

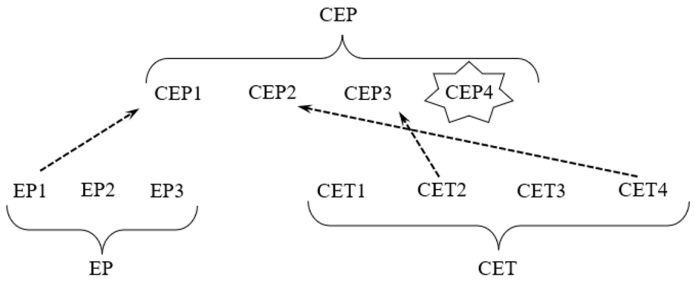

Figure 1: The most relevant theoretical parts of classical evolutionary psychology (EP) and Campbell style cultural evolutionary theory (CET), which cultural evolutionary psychology (CEP) generalizes in a synthetic attempt. CEP's innovative and most important assumption is (CEP4), by the help of which it exceeds its theoretical ancestors. Here, the arrows stand for transformative relations between the respective core assumptions, e.g. (EP1) transforms into (CEP1) in the context of the new synthetic theory.

From EP, (CEP1) adopts (EP1), but in a weaker notion of modularity, as Fodor (1983) had in mind; it stands more in line of Barrett and Kurzban (2006). CEP rejects (EP2) in denying that the relevant modules that are responsible for our human cultural uniqueness have been delivered by genetic evolution. CEP also rejects (EP3), since it denies that we have 'Pleistocene minds' and provides evidence that our minds are more agile and that we have the potential to radically transform cognitive development, i.e., the way we think, and not only what we think about.

Even though CEP does not generally neglect *any* form of genetically evolved psychological adaptations, it renders "the Small Ordinary components of the *genetic starter kit*" (Heyes 2018a, p. 213) as by far not potent enough to provide the basis for human cultural evolution of cognitive products, and by this blocking a too strict form of reductionism as sometimes attributed to EP. Rather, so the main innovation of CEP, the cognitive mechanisms are formed by cultural evolution as well. (CEP2) is deeply inspired by (CET4), Campbells 'dual inheritance argument', but it exceeds the idea by implementing a cultural

evolution of cognitive mechanisms. (CEP3) equals (CET2). However, CEP rejects (CET3), the 'argument from natural origins'. Instead, it sides more with (CET4). (CEP4) is by far the most important part of CEP, making up for its most innovative contribution, and doing the main work. With it, CEP transcends its theoretical ancestors. Figure visualizes this entanglement.

Now, we have said that CEP blocks reductionism from culture to nature, because it renders EP's analysis as mainly relevant for components of the *genetic starter kit*. However, by highlighting the role of cultural learning so much, couldn't a critical stance claim that CEP is a reductive enterprise, just with a tendency that opposes that of EP? In other words: is CEP not simply some form of 'cultural reductionism'? This is not the case, because CEP does not postulate that all relevant features of cognitive mechanisms can be explained by culture. To the contrary: CEP has parts of EP as important elements: the 'starter kit', the hypothesis of mental modularity, but also the more general focus on the mind and evidence from the cognitive sciences. CEP merely drops some assumptions of EP – most importantly (EP2) and (EP3) – and enriches it with (CEP2) and (CEP4). [11] By also recognizing the relative importance of some genetically inherited basic cognitive mechanisms, which make cognitive gadgets possible (starter kit) CEP is not in the danger of becoming some form of cultural reductionism, i.e., a culturally relativistic position that would deny any amount of genetic contribution to human psychology and social behavior.

This means that in light of CEP, evidence E (for the cognitive mechanisms or as Heyes calls them: 'mills') can be separated into E_1 (evidence for cognitive mechanisms as culturally learned) and E_2 (evidence for the genetically inherited 'starter kit'; we will provide more details on this distinction in our discussion in section 4.2). CEP therefore seems to take a preferable middle ground between biological 'imperialism' on the one hand, and cultural 'relativism' on the other.

As we stated at the beginning of this subsection, CEP arrives at its most important core assumption, the assumption of 'cultural learning' (CET4) by theoretical *generalization*. Efforts of applying evolutionary theory and methods in other domains than the life sciences have long been called "generalized Darwinism" (Aldrich et al. 2008) or "generalized evolution" (Schurz 2021). Most prominent of course is the theory of cultural evolution, which is a generalization of evolutionary thinking into the social domain. Now, CEP generalizes cultural evolution in such a way, that it enables the evolution of our cognitive abilities, as well. In other words: CEP *expands* the explanatory frame of cultural evolutionary theory in a radical way. More radical even, than proponents of cultural evolution (for example dual inheritance theory) have ever done. As we will see in section 4.2, some of these proponents mostly focus on structural similarities and by this their approaches amount to, what we called above, forms of unification by analogy. As we have argued here, CEP does more. It provides a theory based on principles CEP1–CEP4 that links natural and cultural evolution not just via structural similarity claims, but by recursive intertwining.

We want to label this specific CEP generalization a 'generalization by re-

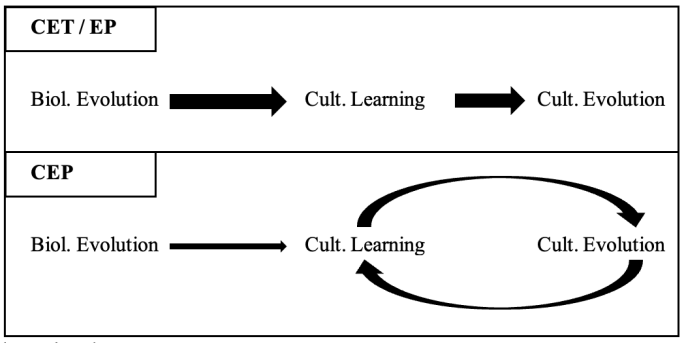

Figure 2: Explanatory differences between CET/EP and CEP, modified after Heyes (2018a, p. 14). EP and CET imply that the biological evolution of our species produced cultural learning, which then produced cultural evolution (thick arrows). CEP suggests that only a small set of innate cognitive abilities, the 'starter kit' contributed to the emergence of cultural learning (thin arrow), which then created mechanisms, which are themselves products of cultural evolution (feedback loop). Cultural Learning and Cultural Evolution continuously enforce each other.

cursion', since we observe a quite different picture of the evolution of human cognition and of human cultural evolution, than CET or EP provide. Figure 2 shows this difference. While CET and EP assume that biological evolution of our species produced cultural learning, which then produced cultural evolution, CEP suggests that only a small set of innate cognitive abilities, the 'starter kit' contributed to the emergence of cultural learning, which then created mechanisms, which are themselves products of cultural evolution. [12] This creates a *recursive* feedback loop in which cultural learning and cultural evolution continuously enforce each other. The better we become in transmitting not only cognitive products but cognitive mechanisms to other people, the more complex our cultural environment becomes in terms of cultural artefacts and behavioral patterns. The more complex this environment gets, the more effective we become in cultural learning, and so forth. This recursive kind of 'cultural bootstrapping' is responsible for the very complex cultural environments, which our modern globalized culture has evolved into.

But is this new picture of CEP empirically justified? We will deal with this question in the next section.

3 Kinds of Gadgets – Kinds of Evidence

We spelled out why we think that CEP has more explanatory potential by employing what we call a 'generalization by recursion', but can it ultimately also deliver on that promise? More precisely, can its most innovative assumption –

(CEP4) – be seen as empirically justified? This section will shed some light on the empirical side of CEP, i.e. the kinds of evidence that it puts forward. In particular, we will show why current data from cognitive science and cognitive psychology speak in favor of cognitive mechanisms as products of cultural rather than genetic evolution. We will discuss evidence for two prominent psychological mechanisms: imitation and mindreading.

To date, evidence relating to six cognitive faculties or modules has been examined in detail within CEP: imitation, language, metacognition, mindreading, morality, and selective social learning, see Heyes and Frith (2014), Heyes (2016), Heyes (2018a), Heyes (2018b), Heyes (2019), Heyes (2021), and Heyes, Bang, et al. (2020). In each case, the evidence is drawn from comparative, developmental and cultural psychology and from cognitive neuroscience. This evidence indicates the "wealth of the stimulus" (the obverse of Chomsky's 1965 "poverty of the stimulus"), i.e. that observed variation in the way a cognitive faculty operates – across species, adults within a human population, cultures, and in the course of childhood development – is due, not to genetic variation, but to variation in sociocultural experience. In other words, the evidence indicates that these faculties are cognitive gadgets (CEP's unifying claim) rather than cognitive instincts (EP's claim).

Imitation is the longest-serving category of cultural learning. Scientists have been claiming for more than a century that imitation involves complex computations specialized by genetic evolution for high-fidelity cultural inheritance, and that this cognitive instinct has played a crucial role in allowing humans to make and use tools. Mindreading, the ascription of mental states, is classed as a form of cultural learning because it is likely to be the key ingredient of human teaching. Effective teaching involves many other cognitive and motivational skills, including social tolerance and attentiveness, but mindreading stands out as the most likely candidate for a human-specific cognitive adaptation for teaching. Humans are better able than any other species to copy the topography of body movements – the way in which parts of the body move relative to one another (Meltzoff 1988). We use our prodigious capacity for imitation to acquire the facial expressions, bodily gestures, and ritualistic movements (e.g. dance and sports), that promote cooperation with members of our own social group, and act as shibboleths setting us apart from other groups. Since the 1970s it has been widely believed that imitation is a cognitive instinct; made possible by a powerful genetically inherited mechanism that relates the "felt but unseen movements of the self with the seen but unfelt movements of the other" (Meltzoff and Moore 1997, p. 179). [13] In the last 20 years this consensus has broken down for two reasons. First, the cognitive instinct theory of imitation was based on experiments suggesting that human newborns can imitate a range of facial expressions, but these experiments have failed to replicate (Slaughter 2021). For example, in a study of more than 100 neonates, using gold standard testing methods, (Oostenbroek et al. 2016) failed to find evidence of imitation of any of the nine gestures tested. Second, evidence is mounting that the capacity to imitate depends on a vocabulary of learned sensorimotor associations. Each of these associations links a visual image of an

action with a representation of how it feels to perform the action. They are forged by self-observation – for example, when babies watch their own hands in motion – and, crucially, through social interactions in which children engage in synchronous activities (e.g. playing pat-a-cake) or are imitated by adults. Evidence supporting this cognitive gadget model of imitation comes from behavioural and neurophysiological experiments showing that, even in adults, the propensity to imitate is highly plastic. A brief period of incongruent sensorimotor experience, in which participants observe one action while performing another, is sufficient to block or reverse an automatic tendency to imitate the trained movements, see Heyes and Catmur (2022), Catmur, Walsh, and Heyes (2009). Convergent evidence comes from naturalistic studies of mother-infant interaction. Mothers who initiate more imitative interactions have infants who do the same (Markodimitraki and Kalpidou 2019), and the effect is action-specific; maternal imitation of facial movements predicts infant imitation of face but not hand movements (De Klerk, Lamy-Yang, and Southgate 2019).

What about *mindreading*? Increasingly, the development of mindreading looks like the development of print reading or literacy, a skill that we know is not 'in our genes' because scripts have been around for only 4.000 years, not enough time for us to have evolved a reading instinct, see Heyes and Frith (2014). For example, parents and other adults scaffold the development of print reading by exposing children to easy-to-read words like 'cat', before hard-to-read words like 'yacht'. Similarly, when talking to their infants, mothers mention easy-to-read mental states, such as desires and emotions, before hard-to-read mental states, such as beliefs and knowledge, and the frequency of developmentally appropriate references to mental states predicts the children's later development of mindreading skill (Taumoepeau and Ruffman 2008). Instruction is also important in the development of both print reading and mindreading. Just as children are instructed in rules of pronunciation (e.g. told what '-tion' sounds like when read aloud), in conversation with their children, mothers make "causal-explanatory" statements that specify relationships between situations, behaviour and mental states (e.g.: He is smiling because he is happy; He is happy because he is playing with the puppy), and the frequency of these causal-explanatory statements predicts individual differences and cultural variation in the development of mindreading citecit:slaughter2012HowCon. These findings, and many others, suggest that people learn to read minds through social interaction with skilled mindreaders in their social group, and especially through conversation about the mind. Some of the additional evidence comes from natural experiments. For example, deaf people who had been deprived of conversation about the mind because they learned Nicaraguan Sign Language (NSL) when it included very few mental-state terms were less likely to pass a false-belief test than a second cohort who had learned NSL later, when it contained a wider range of mental-state terms (Pyers and Senghas 2009). The first cohort was 10 years older than the second cohort; they had had 10 more years in which to introspect and test hypotheses. Therefore, if introspection or science-like learning, rather than conversation, were crucial for the development of mindreading,

one would expect the first cohort to be better, not worse, at ascribing false belief.

Both discussed cases indicate that the main hypothesis of CEP, i.e. the claim that cognitive mechanisms are gadgets rather than instincts, is well aligned with recent findings in this field and, what is more, that it even accounts for an interrelation between cognitive products (e.g. learned behaviour) and cognitive mechanisms (e.g. imitation and mindreading). [14]

4 Discussion: Possible Objections against CEP

In this section, we will discuss two possible objections against CEP. These objections are more or less related and follow quite naturally from one another. The first will deal with the well-known problem of 'unitization', which has befallen the field of memetics some time ago, already. The second will put emphasis on another cultural evolutionary theory, dual-inheritance theory (DIT), and see whether CEP is superfluous in light of DIT. We will argue that, in fact, DIT either remains with structural similarities and, hence, provides only a structural or analogical unification; or it expands its territory on the basis of EP and by this falls prey to the same problems. For this reason, CEP with its focus on recursive feedback loops of social learning is not superfluous. Rather it provides a real unification by generalization.

4.1 Just like Memetics, CEP cannot solve the 'Unitization Problem'

A tripartite distinction between (i) *historical*, (ii) *population-based*, and (iii) *selectionist* approaches within the domain of cultural evolution can be found in the recent works of some prominent authors, including Brusse (2017) or Lewens (2015). Lewens states that explanatorily (and historically) (ii) is nested in (i) and (iii) is nested in (ii). 'Nested' simply means how conceptually general your approach is. Heyes (2018a, p. 35), following Campbell (1965), explicitly pursues (iii) with CEP, similar as 'memetics' did. Such a selectionist view, on the other hand, has to deal with the problem of 'cultural fitness', see Ramsey and De Block (2017) for a deeper investigation. It is of utmost importance for CEP to identify *variants* of cognitive gadgets that do compete for mental resources and can be subject to cultural rather than genetic selection. In postulating a cultural evolution of cognitive mechanisms, we think that a major question becomes pressing for CEP, at least in the long run: What is it that cultural selection acts upon in the case of a cognitive mechanism?

In biological evolution, the variants are either genes (alleles), i.e. parts of the DNA, or phenotypic variants that can be contrasted against other such phenotypic variants. 'Memetics', the theory of memes, has (after more than 40 years) not succeeded to deliver clearly observable units for cultural evolution, thereby converting itself into an empirical and proper research program. Heyes (2018a, p. 37) claims that cognitive mechanisms may be easier to unitize

than cognitive products. Andrew Whiten, a proponent of DIT, indicates the relative importance of the unitization question for CEP, but claims:

> "Heyes suggests that [...], cognitive mechanisms are 'unitized' by cognitive science, making them (as gadgets) more tractable for testing Darwinian selectionist theories of cultural evolution. But don't the same problems [as with memes] arise? Taking the example of language, does a bilingual person have one gadget, or two? Or many?" Whiten (2019, p. 41)

So, what are the units of selection in cognitive gadgets theory? In order to ultimately answer this question, one has to (i) determine what counts as a cognitive mechanism and (ii) whether two distinct cognitive processes are variants of one and the same mechanism, or two different mechanisms. [15]

Cognitive processes have a number of properties. For example, they involve different numbers of stages of processing; they are serial or parallel; they involve representations in different formats (pictorial, map-like, propositional); they vary in speed; and they transform information via different computations, see Heyes (2018a, pp. 66–74). When cognitive scientists make judgements about whether x and y are different processes, they do not apply – even tacitly – necessary and sufficient conditions. Rather, as the number of properties on which there is a contrast between x and y increases, the higher the probability that cognitive scientists will understand x and y to be different processes – and therefore, in the sense of CEP – form different variants subject to cultural selection. In what follows, let us distinguish between an abstract and an empirical understanding of cognitive gadgets.

Let us start with the empirical understanding. CEP does not claim that it is intuitively obvious where one type of cognitive gadget ends, and another begins. As Whiten highlighted, intuition and folk psychology do not offer a steady answer to the question whether bilingual individuals have one language mechanism or two. The key point is that within CEP one does not need to rely on intuition and folk psychology; questions about unitization can be resolved by cognitive science. Resolutions may require hard empirical and theoretical labour, but when achieved, they do not have the arbitrary quality of intuitive judgments – a feature that has plagued memetics, with its focus on *contents* rather than on *processes*. In the case of language, the hard labour of cognitive scientists over the last three decades indicates that bilinguals and monolinguals have different types of language gadgets, but the minds of bilinguals contain one language mechanism not two (Ning et al. 2020), (Shook and Marian 2013). This example shows that – on an empirical level – the unitization problem can be addressed and even lead to some satisfying results in this domain – and this provides a huge benefit towards memetics.

On a more abstract level, it would seem to us that cultural selection acts on certain (probably multidimensional) 'properties' (dimensions include distinctions like: serial/parallel; pictorial/map-like/propositional; amount of speed; amount of information transmission etc.) of cognitive processes. A certain

combination of specific properties constitutes one specific variant. For example: a 'serial-map-like-so and so fast-this amount of information' variant v_1 may compete against a 'parallel-pictorial-so and so fast-this amount of information' variant v_2. This is the picture that CEP delivers. What abstractly determines whether v_1 and v_2 are two variants of one and the same gadget and not simply two different gadgets? The answer might lie in their *function*. If they serve roughly the same (cultural or biological) function, they are different variants, if not, they are different gadgets. Such a functional definition (which does not need to employ necessary and sufficient conditions, only a sufficient amount of similarity, i.e. family resemblance) may not be as physically clear as e.g. the molecular definition of a gene. The functions (the 'phenotypes') of cognitive gadgets can nevertheless be determined via close observation.

This is not the end of the story and a final solution to the unitization problem, of course. Furthermore, functions are multiply realizable and often not unambiguously to identify. In the end, the question whether we have two different mental modules or just variants of the same gadget or which parts of the brain contribute to which culturally learned abilities is an empirical one and has to be settled in a case-by-case manner.

It is not our aim to solve the unitization problem in this subsection, which would require a much more careful and deeper investigation. However, in contrast to the colorful field of memetics, a CEP researcher at least roughly knows where to look, when in search for a cognitive gadget. Memes, however, could be *every* piece of information, that can be socially transmitted (spoken words, written language, digital information, gestures, artefacts, tools, ideas…). [16] Cognitive gadgets are most certainly located somewhere in the brain, which makes empirical operationalization much more tractable. In short: the "search space" of research shrinks heavily compared to that of memetics, when investigating cognitive gadgets and a distinction between an abstract and an empirical understanding of these gadgets is probably helpful.

4.2 CEP is Superfluous, since Dual Inheritance Theory (DIT) already achieved Unification in the Nature-Culture Domain

Another possible objection against the usefulness of CEP might come from a different direction, namely from Dual Inheritance Theory (DIT). Does DIT already provide a nature-culture unification, and does this unification make CEP's generalization by recursion superfluous?

Conventionally, the DIT camp of researchers also goes by the name 'California School', see Sterelny (2017) or Clarke and Heyes (2016). DIT probably started as an independent area of research (also demarcating from sociobiology) in the 1980s, see McElreath and Henrich (2007). Pioneers in the field were Cavalli-Sforza and M. Feldman (1981), or Boyd and Richerson (1985). A very informative area review was written by Mesoudi, Whiten, and Laland (2006). Henrich (2016) recently popularized the approach and Acerbi and Mesoudi

(2015) compare the 'Paris School' sensu Sperber (1996) or Buskell (2017)) to the 'California School' sensu Boyd and Richerson (1985). Historically, CEP as well as (all forms of) DIT descent from the ideas of Campbell (CET).[1] There is, however, an important difference between the two intellectual children of Campbell. While DIT offers a broader population-based view on cultural evolution, CEP aims at a more restrictive selectionist view. As we showed in section 4.1, CEP faces the 'unitization' question precisely because of that. However, there is another crucial difference between DIT and CEP: they provide quite different forms of generalizations.

DIT starts with the empirical observation of striking cultural differences between different groups of humans. Today, these may be less visible than in ancient times, due to the coalescing effects of globalization. These differences cannot be genetically determined or cannot be regarded as the mere result of different environmental conditions alone, since humans in very similar environments and with a highly similar phenotype can still develop very different cultural customs, traditions and practices. DIT makes three central claims, see McElreath and Henrich (2007, p. 2):

DIT1 Cultural capacities as adaptations: The ability of cultural learning arises for once genetically evolved psychological adaptations for observation and social reasoning.

DIT2 Cultural evolution: cultural learning mechanisms give rise to a robust second system of inheritance that operates by different transmission rules and uses different reproductive channels than genetic inheritance, but nevertheless constitutes an evolutionary process. [17]

DIT3 Culture-gene coevolution: Genetic and cultural evolution can influence each other in both, positive and negative ways.

(DIT1) forges a direct link to the principles of EP, in particular (EP2), which we presented above. (DIT2) and (DIT3) are both inherited from Campbell's ideas, in particular (CET2) and (CET3).

Does DIT establish a unification and thereby successfully 'block' the 'imperialistic' attempt of EP? As we see it, in contrast to EP, DIT is meant as a unification. DIT synthesizes/unifies the general idea of Darwinian biological evolution with the idea of selectively transmitted change in human cultures. Having the mathematical framework of, e.g., Boyd and Richerson (1985) and more recent approaches in mind, 'population dynamical models' can be seen as representing abstract unifying structures found in the domains of biology and culture alike – and DIT made that visible.

For two reasons, however, we believe that DIT falls short of unleashing the full explanatory potential of cultural evolution. Firstly, DIT does not satisfyingly account for cognitive mechanisms, the 'mills'. It does not really incorporate them into its explanatory repertoire, which is mostly about the cultural

[1] Heyes (2018a) as well as Boyd and Richerson (1985) mention Campbell already in their introductions, and Richerson and Boyd (2000) bears the subtitle: 'an homage to Donald Campbell'.

evolution of cognitive products ('grist'). Secondly, DIT does not really offer a satisfying explanation of 'cultural learning'. When pressed to speak about the origins of cultural learning, it often merely adopts classical EP, together with all the theoretical burden that comes with it.

> "[...] I have argued that the [DIT] framework currently used to define cultural learning [...] has three shortcomings: (1) it does not acknowledge that cultural learning is, first and foremost, a form of learning; (2) it does not make contact with cognitive science because it focuses on observable behaviour rather than the internal processes that generate behaviour; and, most importantly, (3) it does not characterize cultural learning in a way that distinguishes it, conceptually or empirically, from other kinds of social learning.", (Heyes 2018a, p. 85)

However, the concept of 'cultural learning' is crucial for distinguishing not only biological and cultural evolution, but also cultural from other kinds of social (and 'non-social', i.e. individual) learning. DIT focuses on cognitive products rather than on cognitive mechanisms and the relation between the two (McNamara and Neha 2019, make the same observation). In trying to overcome this issue, Heyes (2018a, p. 86) proposes an alternative framework in which 'cultural learning' is clearly defined as a subclass of social learning that is particularly due to learning mechanisms specialized for cultural inheritance. Examples for those mechanisms are selective social learning (the origin of what DIT knows as 'transmission biases'), imitation or mindreading (see section 3). Against (DIT1), CEP emphasizes that many psychological features, including that of cultural learning, are themselves products of cultural evolution and *not* simply genetic adaptations. Since (DIT1) is the key element of dual inheritance theory that is not inherited from CET, this makes up also for the key difference between CEP and DIT. DIT can only explain what the mind works on, but not *how* the mind works.

Proponents of DIT follow two routes to address the worry of falling short in explaining cognitive mechanisms satisfyingly. [18] Either they are

a silent about where these mechanisms come from and are thereby not committed to a specific view, or

b 'outsource' the question to EP.

Prominent examples of (a) can be found in 'pure modeling' orientated works, like Aoki, Lehmann, and M. W. Feldman (2011) or Kempe, Lycett, and Mesoudi (2014) that employ the same models and by this implicitly focus on structural similarities only. A vivid example of (b) can be found in the formulation of (DIT1) by McElreath and Henrich (2007, p. 2), or in statements like the following, cf. Mesoudi (2011, p. 13):

> "There is no doubt that the psychological mechanisms that allow us to do things like imitate other people or learn languages are the

> product of genetic evolution. [...] However, we are not interested here in these underlying *capacities*, so much as the *contents* of culture: the specific beliefs, attitudes, skills and values that are transmitted using these genetically evolved capacities."

Now, while (a) leaves crucial aspect of cultural evolution underdetermined, (b) entails a pretty implausible EP hypothesis, that sees human cognitive mechanisms as in toto biological adaptations. We hope to have made clear in the previous section 3 that such a statement is by far not as doubtless, and that cultural evolutionary theory should in fact be more interested in the origins of the "underlying capacities", rather than just explanatorily outsourcing them to classical EP.

In contrast to DIT, CEP makes cognitive products and cognitive mechanisms ("capacities") informationally interdependent of each other. Not only that cognitive mechanisms are highly relevant for explaining cultural behavior, but also cultural behavior is highly relevant for the study of 'cultural learning', see Heyes (2018a, p. 14). CEP suggests *informational dependence* of cognitive mechanisms ('mills') on cognitive products ('grist'). Figure 3 depicts how CEP provides a generalized account of cognitive products and mechanisms. Important is the informational dependence relation between E and E_1' (dotted arrow) because it creates an explanatory link between cognitive products and cognitive mechanisms.

It is exactly here, where we can stress a theoretical difference between DIT and CEP in terms of their possible abilities to unify. As we have discussed in section 2, in accordance with Morrisson (2000), we can call an approach that just stresses the importance of mathematical 'structures' as "unifying". We call such a unification 'structural' or 'analogical' unification. [19] In such a way, DIT unifies genetic and cultural evolution by means of a set of common mathematical models, which can be (separately) improved and fed with empirical data *within* both domains. The evidence itself is gathered independently for each domain. DIT is merely interested in cognitive products (E) and either remains silent about cognitive mechanisms (a) or is based on a questionable reliance on EP (b), hence, it provides no plausible mechanism for (E_1'). In particular, it falls short of linking both kinds of evidence. CEP, in turn, may provide an account with even more unificatory potential. This is so, because CEP offers a mechanism ('cultural learning') which makes the kinds of evidence E and E_1' mutually dependent of each other.

One might feel reminded on Dennett's Gregorian creatures, within his 'tower of generate-and-test', see Dennett (1995, p. 377). For him, culturally designed artifacts are not just a result of social intelligence, but also an endower of that intelligence. Tool use, for example does not only require but it confers intelligence. Cognitive gadgets are indeed 'mind-tools', able to generate cumulative culture. The evidence we reported in section 3 supports this, and it is precisely this feature that provides CEP with more unificatory power than DIT.

In accordance with Woodward (2018), we think that due to the many dif-

ferent purposes of a unification in the general philosophy of science, one also best subscribes to a heterogeneous understanding of this notion. As we have argued, CEP is able to extend the coverage of evidential relations of other research programs (such as DIT). There is no 'quietist' need for shying away from the unification in terms of interrelating evidence (a). There is also no need of more or less implicitly outsourcing the task (b). It seems that CEP is able to keep the 'nobility' of EP, without falling victim to some of the problems, that come with the program.

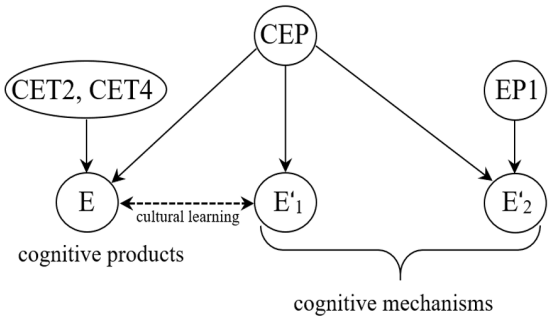

Figure 3: CEP combines the strengths of evolutionary psychology EP (esp. the modularity hypothesis of the mind, EP1) and Campbell's cultural evolutionary theory CET, in particular CET2 (culture gene coevolution) and CET4 (the dual inheritance argument). In addition to both of its conceptual ancestors, CEP finds evidence in cognitive neuroscience that cultural evolution does not only shape the 'grist' (E) of human thought, but also the 'mills'. The latter can be separated into E'_1 (culturally learned cognitive mechanisms) and E'_2 (the innate 'starter kit'). While DIT only explained the evolution of cognitive products (E) and EP failed to explain more than some basic cognitive mechanisms (E'_2), CEP explains both as well as E'_1. Cultural learning is the mechanism that mutually links both domains of evidence.

To conclude: In order to answer the question whether CEP does provide something valuable to the field, since DIT already achieved a (successful) unification in the nature-culture domain, we argued that CEP does not only provide an overarching theoretical framework for both domains (cognitive grist and mills), it also empirically links evidence from the two domains. This should be achieved by the mechanism of 'cultural learning'. Many proponents of DIT do not offer such a mechanism ('quietist position') and, hence, are employing "loose" structural similarities or analogies only or, if they do, they point at classical EP's claim that our cognitive abilities that make cultural evolution possible are simply given by biological evolution ('EP outsourcing'). This latter position, however, has a tendency towards (hidden) reductionism, an approach too strong in order to be carried out successfully. Having argued such, we think that the program of evolutionary psychology as a whole could greatly

benefit from CEP. Furthermore, CEP can significantly complement DIT for exactly these reasons.

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