Teaching Argumentative Skills with LEGO

Building a case for an embodied and enactive approach

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Abstract. When we want to enhance a skill, we obviously need to understand what that skill is. In this paper, I show that education's typical view of argumentative skill is based on the theory of *cognitivism*, a theory that claims that all cognition should be understood as an internal affair, as a process that takes place in the mind. I argue that cognitivism makes highly problematic assumptions, and is unnecessarily restrictive. We should look for theories that allow for external elements and processes to be part of cognition. Focusing on an embodied and enactive conceptualization of the basis of argumentative skills, I develop and test a way to use LEGO in teaching. The preliminary results point at the viability of further developing and testing the LEGO system.

Keywords. Reasoning skills; Teaching philosophy; Embodied cognition; 3D elements.

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1. Introduction

Undoubtedly, one of the skills any philosopher needs to have is the ability to analyze and evaluate arguments. A philosopher should be able, up to a certain point, to construct and deconstruct arguments and hold these up to the light of valid reasoning. When teaching philosophy, we should therefore aspire to enhance this skill.

It seems that typical philosophy teaching, at least the teaching of argumentative skills, assumes that we are training a disembodied ability. Reasoning is taken to be an activity that we somehow do with our minds[1]. This is, of course, not a very satisfactory explanation when we don't believe in immaterial spirits anymore. We must somehow get to a description of cognitive activity in general, and of reasoning in particular, that concurs with science. A common step is to point to neuronal processes in the central nervous system: it is there, and by those processes, that one thinks. This conception is not completely disembodied, but still quite close to a Cartesian *res cogitans*. Only the central nervous system, notably the brain, is deemed relevant for cognition.

This biological explanation satisfies many people working in education. Teaching and learning amounts to brain training[2]. However, for many cognitive scientists, including philosophers of cognition, the biological description doesn't suffice. It is one thing to point at neuronal states and processes, but another to understand how we get from biochemistry to the phenomenon of thinking. A biological state isn't about anything, but just *is*, whereas our thoughts do seem to be about something. Biology alone doesn't get us to the level of mind. This is the challenge: how can we explain the properties of our mental states and activities in a way that doesn't ontologically invoke

1 Oaksford & Chater 2019.
2 Varma et al. 2018.

Cartesian ghosts, or, in Dretske's memorable words, how to «bake a mental cake using only physical yeast and flour»[3]?

From the mid-20th century on, *cognitivism* started to dominate thinking about thinking. Cognitivism argues that thinking consists of processes that essentially involve mental *representations*; entities that have both syntactic and semantic properties. Their syntactic properties make it possible to understand the mental processes as causal-biochemical, and their semantic properties make it possible to understand these processes as being mental, to be about something. Cognitivism thus aims at explaining our everyday psychological understanding of cognition in terms of a naturalized conception of the cognitive processes. Cognitivism's main champion, Jerry Fodor, could, for some time, claim that it was «the only game in town»[4].

However, there is a new game in town, one that promises to be more naturalized and parsimonious than cognitivism. This new game, consisting of many different, yet related so-called E-accounts of cognition (E for embedded, embodied, extended, enactive, ecological, etc.), argues that restricting ourselves to intracranial processing puts serious strains on our theorizing and severely limits our understanding of cognition. Hutto and Myin called this the *can't have* and *don't need* problems of cognitivism: cognitivism can't explain the semantic aspects of its core vehicles of cognition, mental representations, and satisfactory explanations of many cognitive processes don't need them[5].

If these E-accounts are right, the cognitivist assumption limits our understanding of cognition, and thus limits our practices when teaching. We could and should reconceptualize what it is that we're trying to enhance when we're teaching argumentative skills. We should also try to develop means to translate this new concept of reasoning into practical applications for education.

3 Dretske 1982, xi.
4 Fodor, 1975, 27.
5 Hutto & Myin 2013, 22.

In this paper, I first spell out cognitivism's take on a naturalized understanding of reasoning skills. In the second section, I outline cognitivism's main shortcomings. I will present a version of the E-accounts that promises to take away cognitivism's shortcomings, and that supplies a basis for understanding reasoning in a less limiting way. I will argue that our argumentative skills are built on deeply embodied and enactive skills. Finally, I will introduce a first sketch of how the use of LEGO, building on the insights provided by E-cognition, can improve philosophy teaching.

I will use a building metaphor to characterize the overall argument, for reasons that will become clear. I will use the phenomenon of mentality in a physical world as a *foundation* (the basis) for our theorizing, and will construe the main argumentative steps as constructing *levels* (floors that can only be put up if the underlying layer is properly constructed).

2. Cognitivism on reasoning

Basically, deductive reasoning is a truth-preserving process[6]. One might, for instance, reason that

[1]
1. All men are mortal,
2. Socrates is a man,
3. Therefore, Socrates is mortal.

thereby inferring that 3 must be true, if 1 and 2 are true.

A slightly more complicated argument can be found in Descartes' Third Meditation:

[2]

6 In this paper I will use examples of simple deductive reasoning for my analysis, but I suspect that my arguments apply to many if not all kinds of reasoning. See Conclusion.

> It only remains to me to examine into the manner in which I have acquired this idea from God; for I have not received it through the senses, [since] it is never presented to me unexpectedly, as is usual with the ideas of sensible things when these things present themselves, or seem to present themselves, to the external organs of my senses; nor is it likewise a fiction of my mind, for it is not in my power to take from or add anything to it; and consequently the only alternative is that it is innate in me, just as the idea of myself is innate in me.[7]

Here, Descartes argues that

[2′]
1. It is usual that ideas of sensible things present themselves to the external senses of my organs unexpectedly,
2. The idea of God is never presented to me unexpectedly,
3. From 1 and 2: I have not received the idea of God through my senses.
4. It is not in my power to take from or add anything to the idea of God,
5. From 4: the idea of God is not a fiction of my mind.
6. From 3 and 5: the idea of God is innate to me.

In this case, if 1, 2 and 4 are true, 3 and 5 and therefore 6 must be true. Reasoning thus takes us from premises to conclusions in a valid way[8].

This is pretty straightforward on the level of argumentation theory, but an explanation of such a phenomenon as one performing [1] or [2] needs to answer the question as to *how* one performs [1] or [2]. Here is the challenge: if we work under the assumption that minds aren't immaterial souls, we should be able to explain whatever we do in terms of material processes. That means that cognitive processes, such

7 DESCARTES 1911 [1641].

8 Note that the notion of truth is only relevant here to describe the formal properties of deductive reasoning. Whether the deduction uses true or false judgements as premises, is itself not relevant for the validity of the process.

as reasoning, must be materially realized, presumably by the central nervous system. However, reasoning involves propositions, to which we assign properties like meaning and truth. Neuronal states and processes are not true or false, they are not about anything and they have no meaning. They just are and happen. Mental entities involved in reasoning thus have properties that material entities have not. To put it in slightly more technical terms: one's believe that premise 1. is true, is a mental state that supervenes on a material state. The mental state is intentional, meaning that it is about the content of 1., and is the belief that 1. is true. At the same time, the material state that correlates with this mental state is not about anything, and is neither true nor false. This is the foundation that our explanations should be built upon: how can we understand reasoning without taking recourse to metaphysical assumptions about an immaterial mind?

Several theories have been proposed to explain mental phenomena such as thinking [1] in a naturalistic way. Cognitivism, also known as the *Computational Theory of Mind* (CTM), has been the main contender for decades[9].

2.1 Cognitivism

CTM is a generally seen as a version of the *Representational Theory of Mind* (RTM). The RTM claims that mental processes are processes that involve mental representations[10]. Mental representations are the carriers of content, and thinking basically involves the causal interaction between these carriers. Representations carry content because they are about something other than themselves, they are directed at what they represent. This directedness is called *intentionality*, and intentionality is thus the source of meaning, content. Intentionality is by many seen as the *mark of the mental*, distinguishing mental representations from other phenomena[11]. The neurological

9 THAGARD 2018.

10 E.g. FODOR 1987.

11 The mark of the mental used by cognitivism is that of *original intentionality*. Our mental states have meaning, content, by being directed at representations that come in the form

story goes something like this: when we perceive the world, light, or soundwaves, or whatever, stimulate our sensory receptors, which send biochemical signals to other afferent neurons, whose signals end up in the central nervous system. There they get encoded in mental representations, which are said to represent the state of affairs in the outside world[12]. These then causally change the internal state of the cognitive agent, and this change might lead to motor commands, action. Susan Hurley dubbed this the «sandwich model of the mind», where sensory input and motoric output are the slices of bread, and cognition is the filling[13].

Work by Turing and Putnam in the mid-20th century led to the conceptualization of the mind's activity as computation[14]. The mind is said to compute over the formal or syntactic properties of representational vehicles. Computing is a material and causally efficacious process, and when we take mental representations to have both syntactic properties (which make them suitable for computation, implemented as in the neurological story above), and semantic properties (making them have content, by grace of intentionality), we get to the CTM[15]. Representational processing can be understood as both mechanical (representations are individuated by their formal properties), and meaningful (representations have content). Thus cognitivism constructs the ground level of explanation of the phenomena.

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of concepts or propositions. These representations represent the world to be a certain way, and in doing so may or may not succeed (may or may not be true, may or may not satisfy, may or may not be correct). Mental states thus are about something other than themselves, namely about representations. These representations have to do with the state of the world. Even if they are never about anything really existing out there, such as unicorns, they still are representations that we can consider, such as *believing in*, *loving*, etc. Internal representations are the contents of our mental states, and anything that isn't intentionally directed at internal representation isn't part of real cognition (SEARLE 1983, CRANE 1998).

12 The same goes for signals coming from -the rest of- our body.

13 HURLEY 1998, 401.

14 TURING 1950, PUTNAM 1967.

15 FODOR 1975, PYLYSHYN 1984.

CTM’s rendering of [1] would go something like this: When Smith believes that

[1]
1. All men are mortal,
2. Socrates is a man,
3. Therefore, Socrates is mortal,

we can ascribe several mental states to Smith, namely the belief that 1 is true, that 2 is true, and that the correct inferential relation between 1 and 2 necessarily leads to the truth of 3. The computational rendition takes the atomic concepts, such as MAN and MORTAL, arranges them in more complex propositions, such as *all men are mortal*, and infers 3. This arrangement is afforded and constrained by the syntactical properties of the concepts involved. According to Fodor, such thoughts resemble language in that they are composed of simple elements (concepts are like words), which can be combined into complex structures (propositions are like sentences)[16]. Concepts have meaning, and complex structures like propositions have truth conditions: they can be true or false, depending on the state of the world. Thinkers also are (or should be) rational, so as to be able to make sound inferences.

Thus, the sentence “all man are mortal” has a specific meaning because it expresses a proposition that is composed, in a specific way, of concepts. The sentence can also be true or false, because the proposition it expresses may or may not correspond to the state of affairs in the world. Because our thinking is rational, believing 1 and 2 necessitates believing 3. The syntactic processing that Smith’s brain performs, leads from combining 1 and 2 to 3. Good syntactic processing preserves the truth on a semantic level, as in Smith’s case when he correctly asserts 3 on the basis of the semantic properties of 1 and 2.

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16 The Language of Thought hypothesis, FODOR 1975.

It is obvious to cognitivism that Smith's reasoning is an internal affair, implemented by neuronal activity, construed as computation over internal mental representations. In this way CTM justifies the popular image of what true cognition or reasoning is: the ability to think and reason is the ability to internally process representations. In our classrooms we typically aim to enhance this internal ability. Training this ability means training the brain to perform the right kind of computations: computations that make the right kinds of inferences. Teaching argumentative skills is seen as brain enhancement[17]. This is cognitivism's first level in their argumentative structure: if all cognition is internal processing, so is reasoning.

A family of challengers has stood up, united in its rejection of cognitivism's *internalism*. The gist of their argument is that their proposals offer a simpler and more natural account of cognition. In the next section I will briefly sketch the common stance of these so-called E-accounts of cognition, and will focus on Richard Menary's Theory of Cognitive Integration.

3. E-accounts of cognition

E-accounts share the claim that cognition should be construed in terms of processes that comprise brain *and* embodied activity *in* an environment. In this view, the processes and elements of the world outside the brain are *constitutively* relevant, not merely *causally* relevant, as the sandwich model would claim[18]. Reasoning might then be (co-)constituted by such external elements and processes. If that is correct, teaching argumentation should better be understood as teaching the skill to create and manipulate a system of internal *and* external elements. To understand this claim, we will take a look at

17 This is evident from typical modes of assessment: pupils get isolated as much as possible, and they have to demonstrate the abilities of their 'naked' brains.

18 For an overview of arguments and positions, see NEWEN, DE BRUIN & GALLAGHER 2018.

reasons for abandoning cognitivism, and take a look at a promising alternative.

Hutto and Myin call the two main strains of arguments against cognitivism *can't have* and *don't need* arguments[19]. The *can't have* argument takes issue with the status of representations such as claimed by cognitivism. The argument centers on the untenability of the assumption that such things, bearing content, can be understood in a naturalized way. This so-called *Hard Problem of Content*[20] is not solved yet. I will leave this discussion to others, since my concern here centers on the *don't need* argument.

The *don't need* argument leans on empirical and conceptual findings which suggest that the explanation of much of cognition doesn't need representations. For instance, when playing the arcade game of Tetris, players who were allowed to rotate the falling zoids with the arrows on a keyboard, did much better than players who could only use mental rotation[21]; catching a ball in game is not a matter of calculating scenarios through internal representations, but actually uses movement and the angle at which the ball is perceived in an system where sensing and action are directly coupled[22]; a Navy crew collectively steers a vessel, with no one's mind representing all relevant aspects[23]. In such cases, elements of, or actions in the extracranial world, are integrated parts of the system that actually does the cognitive work[24].

At this point one might wonder, as many have[25], whether E-accounts of cognition aren't really just talking about behavior. They seem to give an account of how we act in the world, and are acted upon. These acts surely have to do with causal influences by our bodies and wider environment, but that doesn't mean that we should construe these as

19 HUTTO & MYIN 2013, 22.
20 HUTTO & MYIN 2017, 41.
21 KIRSH & MAGLIO 1994.
22 HUTTO & SANCHEZ-GARCIA 2015.
23 HUTCHINS 1995.
24 See NEWEN, DE BRUIN & GALLAGHER 2018 for more examples.
25 ADAMS & AIZAWA 2010, RUPERT 2004, AIZAWA 2018.

cognitive. After all, it is claimed, intentionality is the hallmark of the mental, and intentionality can only be displayed by internal items, such as mental representations.

That intentionality is exclusively displayed by internal representations, and that true cognition is therefore an exclusively internal affair, derives from the work of Brentano. Brentano merged the concepts of intentionality as *the directedness of an intentional act*, with intentionality as *a property of objects immanent to consciousness* (that at which our consciousness is directed). Brentano concluded that intentionality must be a relation that only holds between consciousness and internal entities or states[26]. Menary, however, argues that there are better ways to understand intentionality[27].

Menary argues that philosophers of a naturalistic bend should drop the aspect of immanence, and take intentionality simply as the directedness at something other than itself. That would eliminate the supposed boundary between the mental and the physical[28]. Building on Peirce and Millikan[29], Menary argues that intentionality is directedness at an object for some further end. This kind of directedness can be displayed by non-human animals, such as the flick of a frog's tongue to catch a fly. Menary states that

> [A]ny representation (or intentionally directed trait) must involve the following three components: the first condition is that the vehicle has certain intrinsic or relational properties that make it salient to a consumer. The second condition is that the vehicle is exploited by a consumer in virtue of its salient properties, thereby establishing the vehicle's representational function (the function of representing an

26 BRENTANO 1973 [1874].

27 MENARY 2009, mostly based on MCDONNELL 2006.

28 Menary's take is quite close to Gallagher's use of Dewey, Hutto and Myin's stress on action, Rietveld et al's Skilled Intentionality Framework, and many other uses of Pragmatism to construe intentionality, meaning, etc, as something we create by being and acting in the world. GALLAGHER 2017, HUTTO & MYIN 2017, RIETVELD, DENYS & VAN WESTEN 2018.

29 PEIRCE 1931, MILLIKAN 1984.

> object/environmental property). The third condition is that a representational triad (a genuine representation) is established only when the representational function is recruited for some further end (such as the detecting of food). The recruitment of the representation in virtue of its function is established as a norm; Millikan (1984, 1993) shows how such norms are established as proper biological functions, but the norm might very well be conventional. Representations established by biological norms I call teleonomic representations, and those established by convention I call teleological representations.[30]

The norms involved demand coordination of consumer and producer. The coordination for teleonomic representations is established by evolution, the norms for teleologic representations are established by convention. They require the coordination of an organism with that organism's environment, meaning that the coordinated directedness of action aimed at some further end, is what intentionality is. This alternative has the advantage of creating continuity between mind and nature, instead of the discontinuity created by the insistence on the special status of internal processing. The difference between the mental and the physical can and should be one of «kinks, not breaks»[31]. E-accounts of cognition thus built the ground level of explanation, one that doesn't use baseless assumptions about representations, and one that can more elegantly explain the cognitive phenomena.

E-challengers therefore *are* in fact talking about cognition, and that makes cognitivism vulnerable to competition from alternatives. Richard Menary's *Theory of Cognitive Integration* (CI) is a promising version of these[32].

30 MENARY 2009, 38.

31 HUTTO & MYIN 2017, 121.

32 MENARY 2007a. CI offers a well-wrought basis on which to understand much if not all of cognition as essentially spread out over coupled neuronal and non-neuronal processes. Future research may point to the operability of other E-versions.

3.1 Theory of Cognitive Integration

CI takes its cue from biology. Key concepts from biology's extended evolutionary synthesis that are of interest to CI are niche construction, reciprocal coupling and neural plasticity[33]. Organisms typically inhabit an environment that they are attuned to, so-called *ecological niches*. A niche is the set of specific possibilities for action that are relevant for the specific organism's goals[34]. Niches are relational entities: two different organisms may inhabit the same environment, but their niches will be different, because their goals and possibilities will differ[35]. The relation of organism and environment is one of reciprocal coupling: the organism is shaped by the environment, and the environment is shaped by the organism. Many if not all organisms shape their environment, thereby constructing niches[36].

Human fitness, like that of many other intelligent species, depends for a large part on our cognitive abilities. We have to cognitively engage with the environment to achieve our goals, and we actively manipulate the salient aspects of our environment to do this. This forms the basis of CI's view of cognition as manipulation, which Menary attributes to Rowlands:

> [C]ognitive processes are not located exclusively in the skin of cognising organisms because such processes are, in part, made up of physical or bodily manipulation of structures in the environments of such organisms.[37]

Instead of relying solely on internal cognitive resources, humans rely on their ability to manipulate the environment. The environment doesn't just *causally influence* cognitive processes 'in the head', but the bodily manipulation *co-constitutes* cognition. Bodily internal *and*

33 LALAND & O'BRIEN 2012.

34 ODLING-SMEE, LALAND & FELDMAN 2003.

35 DAWKINS 1982.

36 BUSER ET AL. 2014. There is a basic evolutionary reason why organisms construct niches: a better fit with the environment makes for better fitness.

37 ROWLANDS 1999, 23, cited in MENARY 2007a, 83.

external elements are part of the cognitive process. These should be seen as parts of a coupled dynamic system, where both (or all) elements mutually constrain each other[38]. Such a system displays properties that cannot be reduced to either of the constituent parts. As Menary states:

> These properties and behaviours are beyond the ability of either subsystem taken on its own. This point is important for understanding cognitive integration, because integrationists argue that the cognitive unit is an unfolding dynamical system composed of internal processes over vehicles that interact with external processes over vehicles. The global behaviour of the system is a product of internal and external processes interacting and working in concert.[39]

This irreducibility makes much of our cognitive processes *hybrid*, straddling both brain and world. As argued earlier, it is our evolutionary background that predisposes us to manipulate and integrate internal and external vehicles. We are adapted to create hybrid cognitive systems. The ability to bodily manipulate our environment is an ancient adaptation[40]. We are also phenotypically highly plastic, in that our neural system is structurally flexible[41]. Our neural system is able to reuse existing structures for other applications, and able to generate new neuronal pathways. Therefore, ontogenetically, an individual is able to acquire the abilities we encounter in cognitive phenomena. This, of course, is the neuronal basis for learning.

The primary systems that we use for dealing with the world are body schemas: subpersonal processes that dynamically govern movement[42]. Menary quotes Gallagher to define body schemas: a body

38 BEER 1995.
39 CI, 44.
40 DONALD 1991, STERELNY 2014.
41 ANDERSON 2014, MENARY 2014.
42 GALLAGHER 2005.

schema is «a system of sensory-motor capacities that function without awareness or the necessity of perceptual monitoring»[43]. Motor programs are repertoires of body schemas that function together. Such programs integrate our body with our environment. As Menary calls it, «my body shapes itself to meet the environment»[44]. Body schemas have neural correlates, as Gallagher explains:

> This extension of the body schema into its surrounding environment is reflected in its neural representations. Not only do bimodal premotor, parietal, and putaminal neuronal areas that represent a given limb or body area also respond to visual stimulation in the environmental space nearby, for some of these neurons the visual receptive field remains 'anchored' to the body part when it moves.[45]

Body schemas are integrated with the environment in that they are tuned to the affordances for action[46]. Body schemas are thus constitutive of our physical and cognitive engagements with the world. Through training and learning, individuals acquire the skills needed for effective manipulation. These skills are basically adapted body schemas, built upon by enculturation.

CI agrees with cognitivism's central claim that cognition has to do with processing information-bearing vehicles. Menary, however, argues that these vehicles are not necessarily computable internal representations. The mark of the mental isn't some exclusively internal thing, but basically «that cognitive processes involve the manipulation of information-bearing vehicles in completing a cognitive task»[47], where cognitive tasks are taken to be a collection of intuitively recognized activities such as perceiving, remembering, making inferences, problem solving etc. Cognitivism just begs the question:

43 MENARY 2007a, 79.

44 MENARY 2007a, 80.

45 GALLAGHER 2005, 37.

46 GIBSON 1979. Affordances aren't mental entities, or objective properties of the environment, but possibilities for a subject.

47 MENARY 2009.

the question why we would want to count the processing of external vehicles as cognitive, can well be answered by the question why we wouldn't.

CI thus gives a naturalized explanation of the full range of cognitive phenomena, from basic action-reaction systems, up to highly skilled abstract reasoning. Continuity between these phenomena is established by arguing for manipulation as a constant in cognition, based on a dynamic systems account of coupling. A phylogenetic and an ontogenetic explanation is added to this description by using the biological mechanisms of adaptation, extended phenotypes and neural plasticity. Cognition turns out to be the skillful manipulation of cognitive vehicles, no matter where these vehicles are located. All that matters for an entity to be a proper part of cognition is the integration in a process that is aimed at completing a cognitive task. This is the first level built on top of E-cognition: an account of *how* external elements and processes can be co-constitutive of cognitive processing.

If this is correct, cognitive activities can be understood without taking recourse to an entirely internal representationalist story. In the next section I will use CI to give an embodied and enactive account of what happens when one is reconstructing Descartes' argument (the one we encountered in section 1). I will also present the use of LEGO-blocks for teaching argumentation.

4. Getting better at reasoning through LEGO

According to CI, external information-bearing vehicles can be, and often are, integral parts of cognition. This could apply to *reasoning* as well. There are several elements and processes that could form part of (re)constructing arguments. In verbal interactions, one tests one's arguments in a reciprocally coupled dynamic system[48]. In writing, parts of the system are used in feedforward and feedback loops[49]. In

48 De Jaegher, Di Paolo & Gallagher 2010. Gallagher 2013.

49 Menary 2007b.

this paper, I focus on the role the construction toy called LEGO can play in enhancing reasoning skills. I claim that our cognitive ability to understand arguments builds upon deeply engrained motor programs for building, and that using LEGO taps into these.

Nuñez, taking his cue from the work of Lakoff and others, argues for the primacy of bodily experience for understanding the human mind[50]. He examines the way in which we express concepts about time: all known languages take expressions that have their basis in spatial experience to talk about time. The future is *ahead* of us, the past *behind* us, time is a *succession* through space. He concludes that we see time events as things in space[51]. Cognitive linguistics, taking our vocabulary on space as the source domain, and the use on time as the target domain, speaks of *inference-preserving cross-domain mapping*[52]. That means that we use words from a domain we are intimately familiar with (in this case the spatial domain), and apply them to a domain we are less familiar with (in this case time). Importantly, we use the inferential structure from the source domain, and project this onto the target domain.

Our expressions and the concepts and propositions we think in, are intimately entwined. Therefore Nuñez argues that if we express ourselves in primarily embodied language, we think in concepts that are primarily embodied. Long before we learn how to think about time, we were able to think about space, and thinking about an abstract domain like time thus builds upon the concepts of space.

A similar relation between source domain and target domain exists between the domain of construction and reasoning. We *build* arguments, which should have a *solid* foundation, *robust* inferential relations, a *strong* structure, where *sound* conclusions are *based on* premises, etc. An argument should, ideally, resemble a sturdy building. Following Nuñez, we can understand this as inference-

50 Nuñez 1999, Lakoff & Johnson 1980, 1999, Lakoff 1993.

51 Nuñez 1999, 46.

52 Nuñez 1999, 45.

preserving cross-domain mapping[53]. Our intimate familiarity with physically building gets mapped onto the less familiar domain of reasoning. To see how this linguistic mapping actually contributes to our cognitive ability to reason, we must look at how CI would analyze this.

Gallagher gives an illuminating example of how skilled embodied and enactive manipulation can be understood[54]. He considers a stone mason who builds a wall between fields, using natural stones. As an experienced mason, he expertly picks a stone from a pile and fits it in the wall. His visual exploration, complemented by the haptic feedback of the fit, creates the performance. The mason doesn't measure the gap in the wall, and doesn't measure the stones in the pile, as the cognitivist would claim. He picks up on the affordances and constraints offered by the gap and the stones, and actively seeks the proper fit. The stone mason has a history in which he acquired the skill to couple with the wall and the pile. By building, he is part of a dynamic system that comprises his brain, his body, the wall and the stones. The dynamics of the system constitute the cognitive activity.

In a sense, we all have some degree of competence in building, innate or acquired. From an early age on, we hone the skills for stacking, constructing and balancing. These skills are implemented in our plastic neural system as motor programs, which get activated when we are in a context in which we are required to stack, construct, etc. When we have to pack our luggage in the trunk of a car, or when we try to evaluate whether a construction is strong enough to keep our weight, we activate these programs. In doing so, we actively use the familiar protocols: we fit, we stack, we connect, we balance, etc. Following Nuñez, we can see how the familiar domain of building acts as a source domain for less familiar activities, such as doing deductive reasoning. The familiar protocols, embodied in our motor programs, are used when we are required to reason. This is the second level in

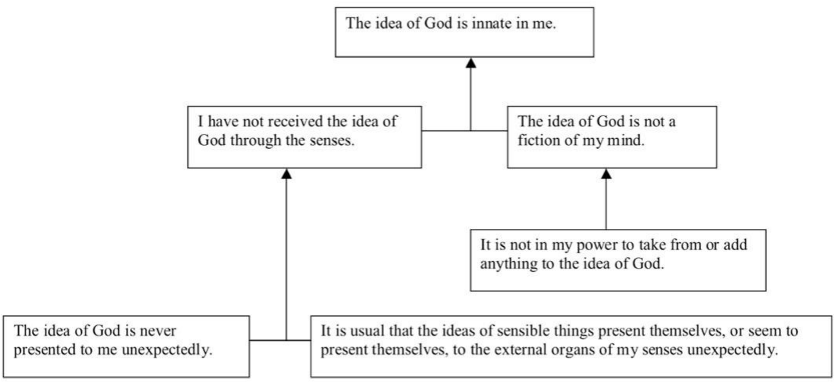
53 Lakoff and Johnson already observed the relation between arguments and building. LAKOFF & JOHNSON 1980, chapter 10.

54 GALLAGHER 2017.

our argument: if cognitive phenomena are best understood as processing in hybrid systems, so is reasoning.

The example of [2] we used in section 1 can be reconstructed as in diagram 1

Diagram 1[55]



Harrell demonstrates that using such diagrams improves critical thinking skills, such as deductive reasoning[56]. However, even if it has spatial properties, the improvement can still easily be analyzed by cognitivism: the linguistic meaning of the premises and conclusions determines their roles in the deduction.

4.1 Constrained LEGO

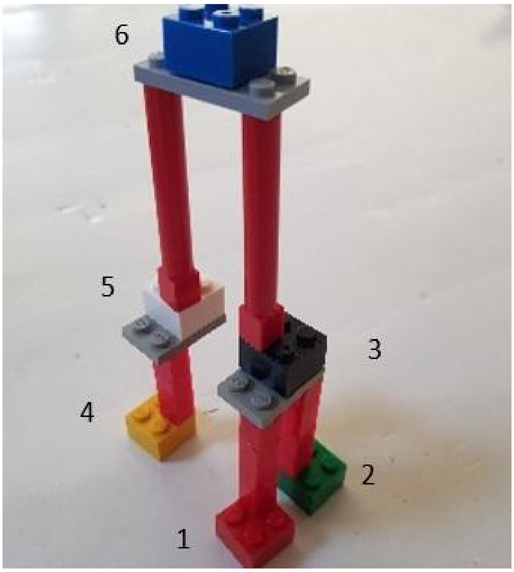
LEGO is a familiar toy construction material, known for the myriad ways in which the pieces can be fitted together. One can express deductive reasoning by assigning meaning to pieces of LEGO and arrange the pieces as in Diagram 1. One could, for instance, make cubes play the part of premises, use cylinders for preliminary

55 HARRELL 2005.

56 HARRELL 2005.

conclusions, use a pyramid for the final conclusion, and use pillars for inferential relations. One might built something like Structure 1 to express [2].

Structure 1, with the elements of [2′] inserted as numbers



Structure 1 is basically a 3D version of Diagram 1, needing a legend to make sense (to mean anything). Constructing this is a conscious internal activity, because the constructor has to consult the legend to see what it is that she's doing. As far as cognitivism's concerned, the only embodied activity involved is the actual putting together of the bricks, as the motoric expression of intentional internal processing. The content of the bricks is derived from the content that the builder has in mind. LEGO bricks thus make no real contribution to the cognitive activity of reconstructing Descartes' argument. In this view, all processing is still easily construed as internal.

LEGO bricks simply afford too much for our purposes. The proper way to construct something like Structure 1 needs explicit instructions as constraints. To make the bricks into something that could be part of an integrated cognitive system, the combinatorial possibilities need to be limited.

A more fine-grained categorization of the role of the bricks is needed, and a physical limitation of the affordances they offer to fit these roles. For reasons I'll discuss in Section 3, I adopted Immanuel

Kant's system, which labels judgements under four heads: *quantity*, *quality*, *relation* and *modality*, with each containing several *moments*[57]. Taking the basic Subject falls under Predicate (*S is P*):

- Quantity:
  - *all* S's are P
  - *some* S's are P
  - *this particular* S is P.
- Quality:
  - P is *affirmed* of S
  - P is *denied* of S
- Relation:
  - S *unconditionally is P*
  - S is *either* P, *or* not-P
  - If S, then P
- Modality:
  - S *factually* is P
  - S *possibly* is P
  - S *necessarily* is P[58]

When we apply these labels to the conclusion of [2], for instance, we get the following: "The idea of God is innate to me" is about a specific S (the idea of God), affirms P (is innate to me), states that the relation holds unconditionally (is), and that S factually is P (the idea factually is innate). Categorization like this informs the (re)construction of arguments. It matters a great deal, for instance, whether premise 1 from [1] ("all men are mortal") is stated as a factual or a necessary truth. It matters for the conclusion because it determines whether Socrates is contingently mortal or necessarily mortal. As [1] stands, Socrates' mortality might be a matter of fact, not of necessity. Likewise, if the moment of quantity of the first premise would have been that some (or most, or at least one) men are mortal, the

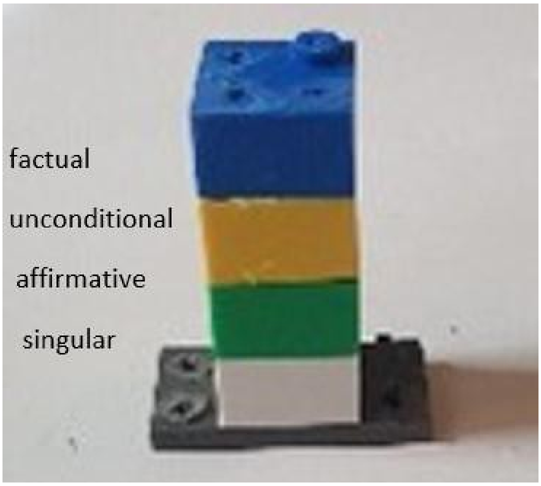
57 Kant 1998 [1781], B95.

58 For simplicity's sake, I have skipped the moment of *infinity* under the head of quality.

conclusion wouldn't follow, and the whole argument would be invalid.

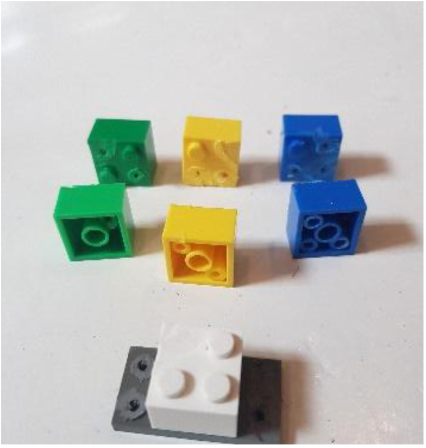
To constrain the LEGO bricks to specific Kantian roles I selectively removed studs from the top and plugged holes in the bottom. Each statement was to be labelled under the four heads, instantiated by four manipulated bricks. The change to the bricks interfered with their interchangeability, thus restraining possible manipulation. I assigned quantity to white (one specific S), grey (some S's), and black (all S's) bricks. I assigned quality to green (affirmative) and red (negative) bricks. I assigned relation to yellow (unconditional), brown (either, or), and pink (if, then) bricks. Finally, I assigned modality to blue cubes (factual), blue cylinders (possible), and blue pyramids (necessary). These four types of brick express all Kantian aspects of judgement, and, when stacked, stand for a specific judgement. In this system, the conclusion of [2] looks like Structure 2.

Structure 2



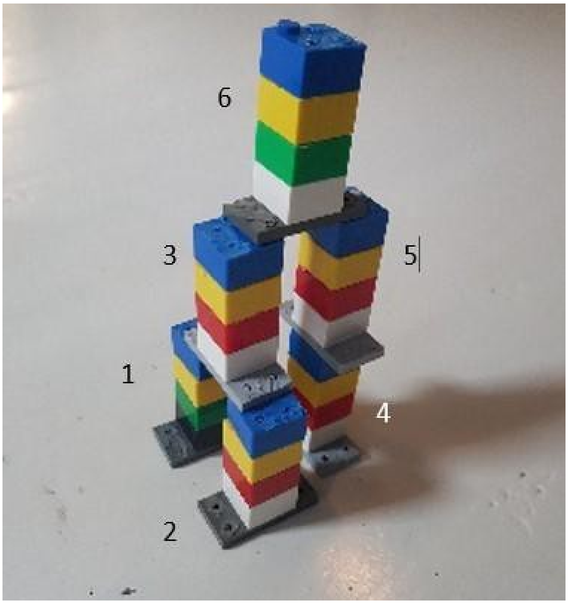
Build on a grey base, the bricks express the syntactic properties of "The idea of God is innate to me". To avoid the possibility of assigning contradictory properties to the same judgement, or of leaving out a property, the bricks cannot be fit in any other way. The place of white in Structure 2 can be occupied by a grey brick or a black brick (belonging to the same head, or category), but not by a brick from another head. It is also impossible to skip a category. Figure 1 shows how this is achieved.

Figure 1, studs removed and holes plugged



To build [2] one needs 6 grey bases, 5 white bricks (pertaining to one specific token S), 1 black brick (pertaining to all S's of a type), 4 red bricks (denoting negation), 2 green bricks (denoting affirmation), 6 yellow bricks (all judgements are unconditional), and 6 blue cubes (all statements are factual). The structure of [2] would then look like structure 3.

Structure 3: with the elements of [2′] inserted as numbers



Finally, we have reached the third level of our argument: if reasoning can be understood as a hybrid process, handling physical items, such as LEGO bricks, can be co-constitutive of reasoning. Now we can put the integrity of this argumentative structure to the test.

4.2 Pilot

In a pilot, I did a pretest on deductive reasoning with my pupils (n=15, pre-university level, ages 14-16). In the previous year, I gave them a 4-week course on informal logic, using Kant's system[59]. The pupils therefore knew what validity is, and, importantly, knew how to identify constitutive statements. In this test, I posed them 10 questions, some like [3]:

> [3] Teacher Mary knows that pupils are always busy, or pretending to be busy. Pupil John claims he didn't do his homework because he was too busy doing something else. Mary knows that John often lies. Mary decides that John needs to get punished for not doing his homework. Is Mary's reasoning valid? Explain.

Some like [4]:

> [4] All X's are Y's. Some Y's are X's and Z's at the same time. If a Z is an Y, it also is Q. Therefore, being a Q means being a Z, and being a Z means possibly being an X. Is this reasoning valid? Explain.

Most pupils (14) were able to correctly use counterexamples to Mary's conclusion in [3], but many (8) failed to give reasons for the fault in [4]. Even though they did reasonably well in identifying an argument as valid or invalid, their explanations of (in)validity were often nothing more than intuitions. Examples of such explanations were «it just doesn't make sense», «When all Y's are Z's, being a Q doesn't follow», and «All X's are Y's, and some Y's are Z's. Then, if Z is Y, it

59 This is the -mundane- reason why I choose Kant's system. Section 4 discusses my intentions to reshape the LEGO system to fit logic's much stronger tools, Propositional Logic and Predicate Logic. For instance, *all S's are P* is Hx $[S(x) \rightarrow P(x)]$, which could be built by using bricks to denote the quantifier, the variable and the predicates, with the rules of deduction expressed in their connections.

also is a Q, but not the other way around». The group on average was able to explain the (in)validity of 6 out of the 10 arguments given.

I handed 9 of them (control group: alphabetically selected, in one 45 minute session, working in 3 duos and one trio) the written version of [2], the judgements as individuated in [2′] on little pieces of paper that I cut out, and gave them the task of constructing an argumentation scheme from this. Most pupils (7) were able to construct Diagram 1.

Then I handed the other 6 of them (test group: in four consecutive sessions of 90 minutes each, two pupils working alone, two duos) the written version of [2], handed them the 30 pieces of constrained LEGO, and instructed them 'to build it', insisting that they use every piece. During the assignment, I refrained from informing the pupils about the meaning of the bricks, although I did, in two of the four sessions, hand them Diagram 1 (the argumentation scheme). All pupils were able to build something resembling Figure 3. They mixed up green and red bricks, and white and black ones, but the general experience was that they «felt like they couldn't really build anything else».

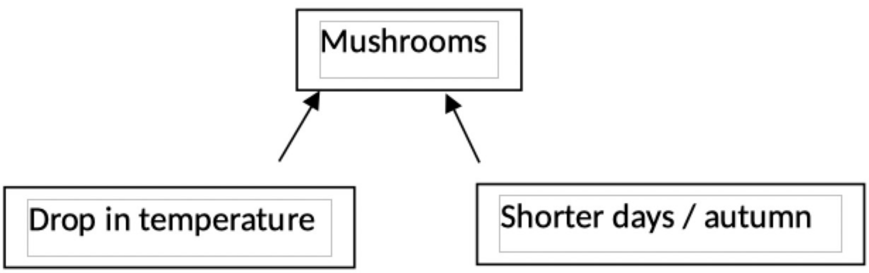
I ran a posttest, one week after the LEGO-sessions. Questions were similar to [3] and [4]. [5] is an example.

> [5] Mushrooms come up when the days get shorter and the temperature drops. It is only in autumn that the days shorten. The mushrooms come up and the temperature drops, so it must be autumn. Is this reasoning valid? Explain.

The control group performed slightly better than in the pretest (averaging 7 out of 10). The test group could identify and argue for 9 out of the 10 arguments, thus showing considerable improvement.

The explanations given by the control group were often as imprecise as the ones given on the pretest, but the explanations offered by the test group were not only correct in more cases, they were also much better argued for. For instance, when evaluating [5], test group pupils came up with explanations such as this: «You can only conclude that it is autumn if, next to a drop in temperature, the days also shorten. Shorter days and a drop in temperature lead to mushrooms, shorter days and autumn lead to each other, but that doesn't mean that mushrooms and a drop in temperature lead to autumn», which is close to a perfect answer. When discussing this answer, a pupil drew an argumentation scheme roughly like figure 4:

Figure 4



As explanation he said that one cannot «put the top on the bottom», meaning that the occurrence of mushrooms cannot lead one to assume that it is autumn, even though the occurrence of autumn or, being biconditional, shorter days (in combination with a drop in temperature) does lead to the occurrence of mushrooms. Not all answers from the test group were this good, but they were considerably better argued for than the answers from the control group.

4.3 Analysis

It seems that working with the LEGO-system gave pupils a better grip on the rules governing deductive logic. In the discussion following two out of the four sessions, pupils argued that the first premise of [2], "It is usual that ideas of sensible things present themselves to the external senses of my organs unexpectedly" should really be categorized under the head of quantity as a grey brick (expressing the form of 'some'), instead of a black one. Meaning that the preliminary conclusion "I have not received the idea of God through my senses" should contain a blue cylinder (expressing a possibility) instead of a blue cube (expressing factualness), meaning that the conclusion should also be categorized in another modality. They thereby expressed an understanding of the syntactic rules involved, i.e. that one cannot infer a factual judgement based on a possibility. In the process of building and discussing, the LEGO-system seems to help the pupils to identify the *relevant* elements (the sentences that *are* part of the argument, as distinct from sentences that are part of the text, but are not argumentatively relevant). Pupils will also find out that the spatial constraints of a 3D-structure forces them to identify the elements as basic (a priori statements and/or empirical facts), derived statements (sub-conclusions), or final conclusions. Finally, the 3D-structure literally shows the relations between the elements, and thus the structure of the argument, making the logical quality visible. The transparency therefore helps the pupils to evaluate deductive arguments.

These findings, and the significant difference in performance in the posttest between control group and test group, suggest that working on deductive arguments through the physical manipulation of objects has an effect on argumentative ability.

In the cognitivist view, the test group should actually do *worse* than the control group in the second written test, because the LEGO lacks explicit meaning, making it unsuitable for easy encoding in mental representations. The pupils from the test group would thus have had *less* practice in internal representational processing.

In CI's view, working with the LEGO system enhances argumentative ability because it builds on a robust system with which pupils are very familiar. Arguments are (re)constructed based on the metaphor of physically constructing, and this metaphor enables pupils to get a better grasp on the rules of building arguments. Pupils actively and physically couple (co-ordinate) their internal mechanisms (including motor programs) with the mechanism afforded by the constrained LEGO, aiming at the cognitive task set by the teacher. We can see that the three conditions for intentionality Menary laid out are satisfied. First: the bricks (the vehicles) have properties that are salient to the pupil. After all, the bricks have different colors and shapes, and offer possibilities for constructing Descartes's argument. Second: the bricks get manipulated (consumed) by the pupil because of their salient properties. Thereby bricks get to have representational functions: because of their physical properties they represent properties of judgements (not because of their semantic properties, which would take us back to endowing them with something like derived intentionality). Third: these representational functions are normatively (following teleologic rules of inductive reasoning) recruited for the end of completing the assignment. Some of these norms are instilled in the affordances and constraints of the bricks themselves. The pupils and bricks create an integrated dynamic system that *is* the cognitive process.

4.4 Suggestions for application in the classroom

Even though the LEGO-system is still in its infancy, a few things can be said about its possible applications in teaching environments. The teacher chooses to explain the concept of validity (explicitly as opposed to truth, as pupils typically confuse those concepts) before or during the comparison of reasoning to building. She might demonstrate argumentation schemes as 2D-constructions (with or without the paper slips), and introduce 3D items that represent the elements of the argument. The Kantian system is, of course, not the most transparent and strongest logical system. As argued, it necessitates the time-consuming constraining of pieces of LEGO. In an analysis of the test I made later on, I noticed that I could eliminate the Kantian elements, and just focus on the constitutive statements (without necessarily going into the 'headings' of these statements). This should also make it easier to find or construct materials to use in the classroom. If one uses differently colored wooden building blocks, for instance, one might also explicate which statements are relevant, and what their different characters (a priori or empirical?) and roles (premise, sub-conclusion, conclusion?) are.

The teacher might first go through the steps herself, as a demonstration. The pupils are then given something like Descartes' argumentation, valid or invalid. The teacher guides the pupils in their efforts in handling this argument with the materials provided, aiming at proper 3D-reconstructions (or, as an intermediate step, aiming at proper argumentation schemes first). Then, pupils create their own argument, first written out, and then physically constructed and presented to their peers and teacher. This process should give opportunity to make the pupils understand deductive inference, by tapping into their basic understanding of the characteristics of building.

5. Conclusion

The phenomenon of mentality in a physical world is the foundation for our argument. Cognitivism's proposal for the ground level turns out to lean on a baseless assumption, and cannot elegantly cover all cognitive phenomena. We laid E-cognition's ground level as a sturdier alternative, suggesting that cognition should be understood in terms of processes which can, and often do, extend beyond the brain. Then we built a first level of Menary's CI, one that fleshes out E-cognition's claim to external co-constitution. The second level was built using motor programs as essential elements in a hybrid system. In CI's view, reasoning might involve processes that integrate embodied motor programs, brain and physical objects. The third level was constructed by using LEGO as part of the hybrid and dynamic cognitive system. If reasoning skills can be understood as hybrid skills, handling physical items can be co-constitutive of such skills.

To test this, the LEGO system was informally tried out. Pupils who practiced with this LEGO system showed improved skill in evaluating arguments.

Cognitivism can still claim that working with the LEGO-system improved intracranial processing, and that the pupils from the test group simply had more practice in deductive logic. However, the results of the informal trial seem to point out that the explanation in terms of activated motor programs has a closer fit to what actually happened. The cognitivist story cannot explain why the test group performed better than the control group. After all, the only difference lay in the handling of material objects. The control group worked with judgements that, being linguistic structures, are meaningful to them, and whose meaning can then be used to structure their inferential relations. The test group worked with plastic bricks that lack meaning, but impose rules of reasoning. Since, as Aristotle knew, the validity of arguments resides in the structure of arguments, or their interrelation by deduction-rules, as we would currently say, and not in the meaning of terms occurring in the arguments, the embodied-enactive approach to logic with LEGO gets closer to the essence of logic.

This points toward the viability of using E-accounts of reasoning in educational practice. Future research will include systematic and substantial empirical inquiry, and reshaping the LEGO-system to express and teach the more current logical systems of Propositional and Predicate Logic.

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