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Why do people pirate? A neuroimaging investigation

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ABSTRACT

It is not uncommon for people to openly admit to pirating information from the internet despite the known legal consequences. Those same people are often less inclined to steal the same physical item from a shop. This raises the question, why do people have fewer reservations with stealing intangible items compared to tangible? Using questionnaires and fMRI we provide evidence across three studies as to the differences between tangible and intangible theft. In a questionnaire (Study 1), participants revealed that across different conditions they were more willing to steal intangible compared to tangible goods. Study 2a used fMRI to reveal that a network involved in imagining objects was more active when participants were representing intangible versus tangible objects, suggesting people have greater difficulty representing intangible items. Study 2b used fMRI to show that when stealing tangible objects versus intangible, participants had increased activation in left lateral orbitofrontal cortex, an area typically activated in response to morally laden situations. The findings from the current investigation provide novel insights into the higher prevalence of intangible theft and suggest that differential neural representation of tangible and intangible items may, in part, explain why people are more willing to steal intangible items.

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Philosopher Locke (1970) first identified the concept of object ownership as the result of labor and property. This ideology extends to both tangible (e.g., clothing, electronic devices, transports, etc.) and intangible property (e.g., intellectual property, soft copy property such as music, photos, and art). As such, it could be expected that the same social rules apply for intangible property as they do tangible, that is, *this does not belong to me therefore I will not interact with it without permission*. However, stealing intangible items is a major problem in society, with many people participating in illegal downloading of movies, music, and software (Gunter, Higgins, & Gealt, 2010). A lot of these people would not steal the same items if they were tangible. The cost of this intangible theft has major consequences for the economy as a whole. Siwek (2007) investigated the influence of internet piracy on the United States economy and showed that a total of $58 billion was lost across all industries. This poses the question, *why do we find it easier to violate moral rules surrounding intangible items than tangible?*

An understanding of morality and our interaction with physical property may help us understand rule violations with tangible and intangible objects. Greene and Haidt (2002) and Greene, Nystrom, Engell, Darley, and Cohen (2004) define morality as an automatic, emotional reaction to an agent or event. Subsequently, these moral emotions (compassion, anger, shame, disgust, and guilt) interact with volitional reasoning to make a moral judgment with regards to how the outcomes will affect people (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Valdesolo & DeSteno, 2006). Indeed, there is ample evidence validating this explanation of morality (see Rozin, Lowery, Imada, & Haidt, 1999; Tangney, Stuewig, & Mashek, 2007) and as such this is the definition that we will abide by in the current investigation.

So why are we more likely to steal intangible items? Cronan and Al-Rafee (2008) and Yoon (2011) used the theory of planned behavior (TPB; Ajzen, 1991) to identify the factors contributing to pirating behaviors. Their findings suggest that those who have positive attitudes toward piracy are more intent on pirating. In addition, they revealed that those who had pirated in the past were more likely to pirate again, and those who had a higher moral obligation (or felt guiltier toward pirating) were less likely to pirate. There is evidence to suggest

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that infringement may be the result of norms propagated within a group. For example, Eining and Christensen (1991) showed higher rates of software piracy were associated with greater beliefs of friends finding this behavior acceptable. In the same study, the authors showed that participants' dissatisfaction with the cost of software predicted greater piracy behavior.

In a more recent study, De Groot, Abrahamse, and Vincent (2013) investigated attitudes toward theft and how they are influenced by a range of factors. They showed that people have more favorable attitudes toward theft when the value of the item is low compared with moderate or high, and also greater negative attitudes toward theft when the theft occurs in a private or clean environment. Moreover, an alternative explanation for why people pirate is that they are simply accessing an inexhaustible resource, and therefore, are not removing the opportunity for others to access the same resource. Indeed Ehlmann (1985) argues that this is the case and that a shift should be made to make software exhaustible to help illustrate there is a cost with infringement and to prevent this behavior.

Manesh (2006) provides an alternative evolutionary explanation and suggests that through our evolution we have interacted more with physical goods, especially with regards to ownership. It is only recently in our evolutionary history that intangible items, such as ideas and software, have been protected by law. Therefore, our brains have evolved prominently to deal with protecting tangible items. As a result, a legal scope is used to differentiate theft (stealing physical goods) from infringement (stealing intangible goods). The hybrid theory of moral cognition (Manesh, 2006) describes a dichotomy between intuitive, immoral behavioral responses, and conscious, amoral behaviors. The former relates to an automatic process that occurs outside of conscious experience and is dependent upon a violation of moral rights for something inherently known (for example, hurting an infant). The latter, describes a more conscious contemplation of evidence in light of the moral decision-making process and behaving accordingly (for example, punishing a child for doing something inappropriate). Goodenough and Prehn (2004) suggest that violations of infringement may require more conscious processing and may not activate, what they term, an affective system (which typically includes the orbitofrontal cortex (OFC) and amygdala) to the same extent as violations of theft.

A consequence of the hybrid theory of moral cognition is the innate property intuition hypothesis (IPIH; Manesh, 2006) which proposes that there may be different neural networks involved with tangible theft and intangible infringement. That is, our brains are "hard-wired" to respond to violations of tangible goods because of intuitive, or inherent, processing. Said differently, the IPIH suggests that stealing physical objects may elicit an intuitive, affective response (similar to experiencing harm through direct contact) in the affective system, whereas acts of infringement do not. It further postulates that this lack of neural activity ultimately results in a normative judgment of infringement.

With regards to moral cognition and moral judgments, there is not one unique neural unit responsible for these processes. Rather there are a wide range of brain areas such as the medial prefrontal cortex, OFC and posterior cingulate cortex which can be involved depending on the moral task that is used (Knabb, Welsh, Ziebell, & Reimer, 2009; Young & Dungan, 2011). While the medial prefrontal cortex is typically involved in more explicit, cognitive moral processes such as the trolley paradigm (Forbes & Grafman, 2010), the OFC has been consistently implicated in neuroimaging studies surrounding more automatic moral evaluations. The OFC has been observed playing a role in many moral based tasks and investigations, including: donation behavior (Moll et al., 2006); understanding psychopathy (Kiehl, 2006; Muller et al., 2008; Raine & Yang, 2006); and sensitivity toward morally ambiguous situations (Moll, de Oliveira-Souza, Bramati, & Grafman, 2002a; Moll et al., 2002b; Moll, Eslinger, & Oliveira-Souza, 2001).

The lateral and medial portions of the OFC also play distinct roles in morality. Meta-analyses on the OFC have shown that the medial portions of the OFC are more associated with monitoring the reward value of different reinforcers, while the lateral portion of the OFC is associated with evaluating punishers that, ultimately, may change ongoing behavior (Berridge and Kringelbach, 2013; Kringelbach & Rolls, 2004). Supporting this, we recently showed that the medial OFC was more active when people reward others while the lateral OFC was more active when participants were harming another person (Molenberghs et al., 2014a). Subsequent fMRI experiments have shown that the increase in lateral OFC activation is directly related to how guilty people feel when harming others (Molenberghs et al., 2015), and how much moral sensitivity they experience when observing a person being harmed (Molenberghs, Gapp, Wang, Louis, & Decety, 2014b).

Aims and hypotheses

Often in moral neuroscience, the emphasis is placed on violations surrounding physical harm-doing (e.g., Decety & Cacioppo, 2012; Decety & Michalska, 2010; Decety, Michalska, & Kinzler, 2011; Yoder & Decety, 2014), however, there are moral rules that extend beyond the domain of physical injury; for example, stealing objects from another person. In the current investigation we were interested in identifying why people are more willing to steal intangible versus tangible items. Specifically, we wanted to test specific hypotheses from the IPIH. To do this, the first study used a questionnaire to identify whether people are more likely to steal something that is intangible in nature.

There are several factors that may influence why a person would pirate information. For example, intangible goods may have frequently zero cost for production compared to tangible information, or it may be an issue of ease of access. There are ample avenues for people to acquire music, movies, software and so on if they have basic computer skills. Alternatively, people may feel that there is nothing wrong with pirating because it is common practice in the community. The design of the current study accommodates for these potential factors by holding constant the cost of production, the ease of access and ensuring the resource is equally exhaustible across tangible and intangible theft. If Manesh (2006) is correct about how people prioritize physical belongings, then we would expect that people would be more likely to steal intangible goods compared with tangible, regardless of the context. Therefore, in Study 1 it was hypothesized that across the board, participants will be more likely to steal intangible compared to tangible objects.

The IPIH further postulates that we are less morally sensitive to crimes involving intangible items because we have less evolutionary experience with them. Due to a lack of experience, it is more difficult for us to represent intangible versus tangible information. To test this prediction, the first fMRI study aimed to identify whether intangible objects evoked more activation in a visual imagery network compared to tangible items. In previous visual imagery investigations, areas such as the dorsomedial prefrontal cortex, inferior and middle frontal gyrus, precuneus, cingulate gyrus and left angular gyrus, have typically been implicated (FeldmanHall et al., 2012; Ganis, Thompson, & Kosslyn, 2004; Stuss & Alexander, 2007; Zvyagintsev et al., 2013). Previous research has shown that seeing and imagining objects relative to scenes leads to increased activation in lateral prefrontal cortex and inferior parietal lobule (Hassabis, Kumaran, & Maguire, 2007; Sugiura, Shah, Zilles, & Fink, 2005). Further evidence implicates the medial prefrontal cortex in a range of imagination tasks (Benoit, Szpunar, & Schacter, 2014; FeldmanHall et al., 2012; Hassabis & Maguire, 2009; Lin, Horner, Bisby, & Burgess, 2015; Ruby & Decety, 2004). Considering previous research into visual imagery we predicted that imagining objects would lead to more activation in an imagery network containing the prefrontal cortex (dorsomedial and lateral components), the inferior and middle frontal gyri, inferior parietal lobule, precuneus, and left angular gyrus, and that this network would be more active for intangible than tangible items.

The second fMRI study tested the second prediction of the IPIH by adding a moral violation (the unlawful taking of an item) to determine whether theft of tangible (versus intangible) items results in increased activation in brain regions involved in moral sensitivity, such as the lateral OFC. Finally, the IPIH suggests that our reduced capability for representing intangible information is why we experience less automatic neural moral sensitivity for intangible theft. To investigate this prediction we tested whether people who have more difficulties representing intangible information in the first fMRI study, showed less activation in brain areas associated with moral sensitivity when stealing intangible items in fMRI study 2.

Study 1: are people more willing to steal intangible items compared with tangible?

Participants

A total of 127 participants (males = 31, M_{age} = 27.69, *SD* = 8.69) completed an online questionnaire for Study 1.

Materials and procedures

A purpose built questionnaire was created to identify why people steal more intangible items compared with tangible. Is it because they feel safe? Is it because they do not feel there are any consequences? Details of the questions and the analyses can be found in Supplementary Table 1. Broadly speaking, the items on the questionnaire were matched on outcome, severity, and context with only the tangibility (tangible, intangible) of the object being different between the items. The questionnaire was created and administered through Qualtrics Survey Design software (Qualtrics, Provo, UT) and participants accessed the link to the questionnaire through means of social media in their own time.

Results

In Study 1, we were interested in ascertaining whether people would be more likely to steal intangible goods compared with tangible goods when a range of commonly associated factors were held constant. Holistically, participants were more willing to steal intangible items across all conditions, regardless if the company was big ($p < .001$) or small ($p < .001$), the items were cheap ($p < .001$) or expensive ($p < .001$), or the cost of the item for the company was the same ($p < .001$). See supplementary materials for the full set of analyses.

We were further interested in seeing whether there were gender or age related differences between participants when considering piracy behavior. Point-biserial correlation analyses revealed that gender was not associated with current or future pirating behaviors ($p = .07$ and $p = .54$, respectively). Age was found to be associated with current piracy behavior ($r = -.29$, $p = .001$) and future piracy behavior ($r = -.41$, $p < .001$), such that older respondents are less likely to be currently pirating or willing to pirate in the future. Finally, we found a significant correlation between current piracy behavior and future behavior ($r = .72$, $p < .001$), whereby the more people were currently pirating the more likely they were to pirate in the future. For the first time, we have provided quantitative data illustrating that people are more willing to steal intangible items compared with tangible. The question remains: is this increased likelihood to steal intangible items associated with differential representation of intangible and tangible goods in the brain?

Study 2a: are tangible and intangible items represented differently in the brain?

Participants

Thirty-five undergraduate participants (female = 20, M_{age} = 24.86 SD_{age} = 5.22) completed Study 2a while 34 participants (female = 20, M_{age} = 25.14 SD_{age} = 5.15) of the original 35 completed Study 2b. One participant did not complete the second experiment due to technical issues. Participants were compensated $30 for their time. All participants provided full written consent to participate in the study which was cleared by the Ethical Review Committee at The University of Queensland. Participants took part in two experiments (Study 2a and b) during the same scanning session.

fMRI image acquisition

Image acquisition for experiments 2a and 2b were conducted in the same scanning session. fMRI data were acquired using a 3-Tesla Siemens MRI Scanner with a 32-channel head volume coil and a gradient echo planar imaging (EPI) sequence with the following parameters: repetition time (TR) 2.5 s; echo time (TE) 36 ms; flip angle (FA) 90°, 64 × 64 voxels at 3 mm^2 in-plane resolution. Each experiment had three runs assigned to it. Whole brain images were generated every 2.5 s collecting a total of 152 functional images per run for the first fMRI study (2a) and 156 for the second (2b). Six functional runs were acquired during the scanning session. The first fMRI experiment ran for approximately 25 minutes which consisted of three functional scans (each approximately six minutes long). A three-dimensional high-resolution T1-weighted image covering the entire brain was acquired after the third run for anatomical reference (TR = 1900, TE = 2.32 ms, FA = 9°, 192 cubic matrix, voxel size = 0.9 cubic mm, slice thickness = 0.9 mm) and lasted approximately four minutes. Following the structural scan, three functional runs were assigned to experiment 2b.

Functional MRI experiment 1

Experimental stimuli included a range of entertainment titles which were either books, movies, music, or software that were familiar to participants (see Supplementary Material for details). There were three conditions; tangible, intangible, and control. During the tangible condition, participants had to imagine a hard-copy, or physical, version of the entertainment, whereas in the intangible condition participants were required to imagine a non-physical version of the entertainment. The conditions were presented in blocks and each block was preceded by one of three letters which indicated the condition for that block (*T* for tangible, *I* for intangible, and an *O* which represented the control condition; entertainment titles that had been jumbled using an online word scrambling tool). Participants were required to passively imagine the entertainment titles depending on the tangibility of the object. In the control condition, participants were instructed to just look at the jumbled words. Participants were instructed that we would be monitoring their eye movements during the task to ensure they were paying attention to the stimuli. For detailed instructions given to participants in experiment 2a see Supplementary Material.

Each of the three runs of experiment 2a had 12 blocks of trials which pseudo-randomly presented three entertainment titles from a list of 40 possible titles (see Supplementary Table 3). Entertainment titles were repeated across conditions within participants such that each participant experienced the same entertainment title as tangible and intangible. The same title was not presented multiple times within the same block. During each block all entertainment titles belonged to the same super-ordinate condition of tangible, intangible,

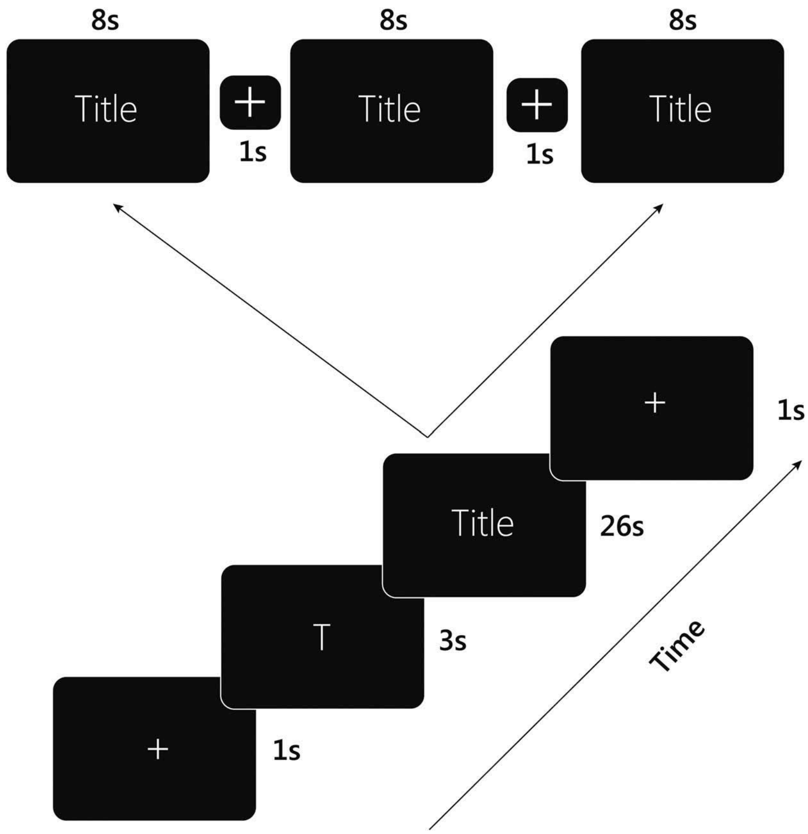

Figure 1. Trial sequence for Study 2a. After being presented with a cue slide for three seconds, participants were exposed to three 8 s stimulus slides that highlighted a different entertainment title. Based on the cue (T, I or O), participants had to imagine each entertainment title respectively as tangible, intangible or just watch the scrambled word. After the third title, participants were presented with a 1-s fixation screen.

or control condition. At the beginning of each run, a 5-s fixation cross was presented. This time corresponded to the acquisition of the first two images from each functional run and these were removed from the analysis to allow for steady-state tissue magnetization. At the start of each block, a fixation cross was presented for 1 s followed by the letter (T, I, or O) which was presented for 3 s (Figure 1). Next, the first entertainment title was presented for 8 s which was then followed by a 1 s fixation cross before displaying the next entertainment title. Between each block a 1-s fixation cross was presented. All stimuli were presented using E-Prime 2.0 Professional software (Psychology Software Tools, Inc.).

fMRI data analysis

SPM8 software (Wellcome Department of Imaging Neuroscience, Institute of Neurology, London) was used in conjunction with MATLAB software (Mathworks Inc., USA) to analyze the functional data. During the first level analysis, all EPI images were realigned to control for any head movements that may have occurred during scanning. We then co-registered the T1 scan with the mean EPI scan and subsequently normalized the T1 scan to the MNI T1 template using segmentation. The same normalization parameters were then applied to the EPI images using standard stereotaxic space parameters of $3 \times 3 \times 3$ mm. Finally, we smoothed the data using a Gaussian Kernel of 9 mm (FWHM). A general linear model was created for the three (tangible, intangible, and control) experimental conditions versus baseline. Blood oxygen level-dependent (BOLD) response changes in each voxel were modeled using a canonical hemodynamic response function time locked to the onset of each block with a 26-s duration. These 26 s corresponded to the total duration of three titles per block to model the effect for the tangibility of the titles (see Figure 1).

In the second level analysis, we incorporated the contrast images from each experimental condition from the first-level analysis into a one-way ANOVA across participants to test whether there were differences between each condition with regards to neural responses. We first created a contrast that compared the combined effect of the tangible and intangible condition with the control condition to identify which brain regions were involved in representing the items across the two conditions. A voxel-level probability threshold of $p < .001$ was used in conjunction with a cluster-level threshold with a family-wise error (FWE) rate of $p < .05$ to define significant activation. We then saved this network as a ROI to investigate any potential difference between the tangible and intangible conditions within this network. Significance for the follow up tests was defined by a FWE voxel-level threshold of $p < .05$ corrected for the size of the cluster.

Results

Comparing the contrast between the combined effect of tangible and intangible with the control condition (T + I—C) revealed increased activation in three clusters. The first cluster had its peak in the dorsal medial prefrontal cortex (dmPFC; 6, 20, 43, extent = 4170, Z = 6.69, $p < .001$) and extended into other areas such as the midcingulate cortex (MCC), insula, left inferior and middle frontal gyrus, and supplementary motor area (SMA). The second cluster corresponded with the posterior superior temporal gyrus (24, −40, 16; extent = 120, Z = 4.83, $p = .032$), and the third with the left angular gyrus (−39, −65, 49; extent 108, Z = 4.60, $p = .044$).

Within this network, compared to imagining tangible items, imagining intangible items led to increased activation in two clusters (Figure 2). The first cluster had its peak coordinate in the dmPFC(−33, 59, 13; extent = 1833, Z = 4.29, $p = .011$) and extended into other areas such as the midcingulate cortex (MCC), left inferior and middle frontal gyrus and supplementary motor area (SMA). The second cluster corresponded to the left angular gyrus (−42, −61, 49; extent = 105, Z = 4.65, $p = .002$). The reverse contrast did not reveal any significant differences.

Study 2b: do we experience greater moral sensitivity for stealing tangible versus intangible items?

Functional MRI experiment 2

Experiment 2b manipulated legality (illegal, legal) and tangibility (tangible, intangible). Participants were exposed to a scenario at the beginning of the study that depicted the participant obtaining an object, either intangible or tangible, and either illegally or legally. Participants were required to imagine how guilty they would feel obtaining this entertainment type (see Supplementary Material for detailed instructions). To discern between the four conditions, Illegal Hardcopy, Illegal Softcopy, Legal Hardcopy, and Legal Softcopy, the following prefixes were added to the entertainment types: IH, IS, LH, and LS, respectively.

Participants were presented with four entertainment types (book, movie, music, and software) that were pseudo-randomly and sequentially presented for 4 s each in a block design. Entertainment types were used in Study 2b (rather than entertainment titles) to reduce the influence of general preference for specific titles which may influence participants' responses. Between each entertainment type presentation, a fixation cross was presented for 1 s (Figure 3). Each entertainment type belonged to the same condition (e.g., illegal hard copy) and at the end of the fourth entertainment type, a behavioral response was recorded which asked participants to make a response about how guilty they felt obtaining the entertainment. Scores ranged from 1 (not very guilty/very guilty) and 7 (very guilty/not very guilty). The starting location of the cursor (red box in Figure 2) was randomized, so too were the anchors of the item; this was to ensure that participants did not elicit a response bias throughout the experiment. Indications of guilty ratings were made by pressing

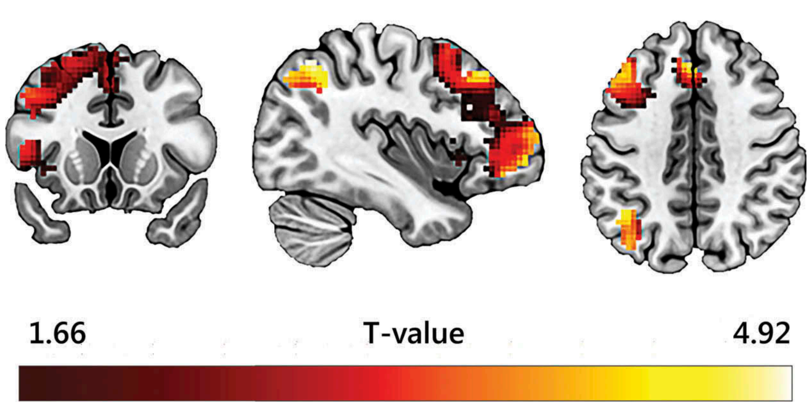

Figure 2. Increased blood oxygen level dependent (BOLD) response activity for the intangible minus tangible contrast displayed on coronal, sagittal, and transversal slices using mricrogl.

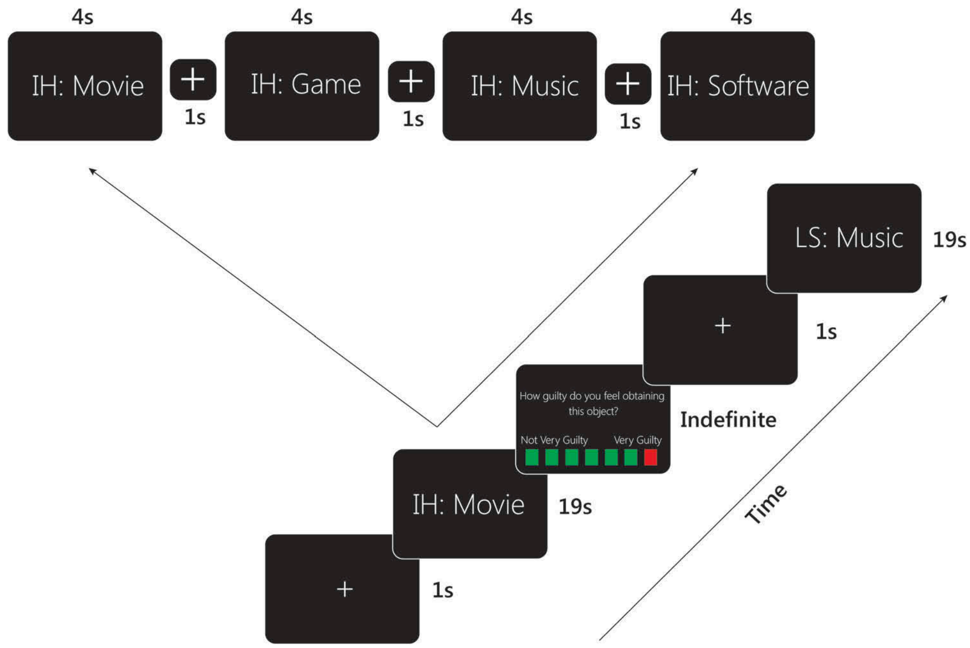

Figure 3. Trial sequence for Study 2b. Participants were exposed to four entertainment types (movie, game, music, and software) which were preceded with one of four prefixes (illegal hard: IH, illegal soft: IS, legal hard: LH, and legal soft: LS). Presentation of entertainment types was randomized within each trial. After the fourth entertainment type was presented, participants had to rate how guilty they felt obtaining the entertainment type by moving a cursor (red box) to the left or right. The red color box denotes the location of the cursor to assist participants in making their decision. On completion of making their response, a fixation cross would appear for 1 s and the next trial would commence.

three different button press responses. The button on the left moved the cursor to the left and the right moved the cursor to the right. When the cursor was at the correct position, the participants pressed the middle button to select the appropriate response. In total there were 12 blocks presented in each of the three runs.

fMRI data analysis

Similar pre-processing of the fMRI data was used in Study 2b as Study 2a with the exception of how conditions were modeled. BOLD response changes in each voxel were modeled using a canonical hemodynamic response function time locked to the onset of each condition with a duration of 19 s. These 19 s corresponded to the onset of four entertainment types presented (Figure 3).

Contrast images from the first-level analysis of each of the four (IH, LH, IS, and LS) experimental conditions compared with baseline were included in a second-level factorial design. We were particularly interested in seeing how obtaining an item illegally compared to legally would lead to increased activation in left and right lateral OFC (anatomically defined using the AAL atlas (Tzourio-Mazoyer et al., 2002) implemented in the WFU pickatlas; Maldjian, Laurienti, Kraft, & Burdette, 2003). This resulted in a significant effect in left lateral OFC and this cluster was then further explored to see if the effect of legality was the same for tangible and intangible items. All region of interest analyses were defined by a FWE voxel-level threshold of $p < .05$ corrected for the size of the cluster. In addition, whole brain analyses were performed.

Results

Behavioral data

A 2 (Legality: illegal vs. legal) × 2 (Tangibility: tangible vs. intangible) within-participants analysis of variance was conducted with guilty scores as the dependent measure. This revealed a significant main effect of legality, $F(1,33) = 234.28$, $MSE = 1.89$, $p < .001$, $\eta_p^2 = .88$, such that when the object obtained was illegally acquired ($M = 5.00$, $SD = 1.16$) people felt more guilty than when it was legally acquired ($M = 1.34$, $SD = 0.64$). Additionally, a significant main effect of tangibility was also revealed, $F(1,33) = 97.70$, $MSE = 0.63$, $p < .001$, $\eta_p^2 = .75$, whereby people felt more guilty for objects that were tangible in nature ($M = 3.85$, $SD = 0.65$) compared with intangible ($M = 2.49$, $SD = 0.83$). Finally, a significant interaction was found between legality and

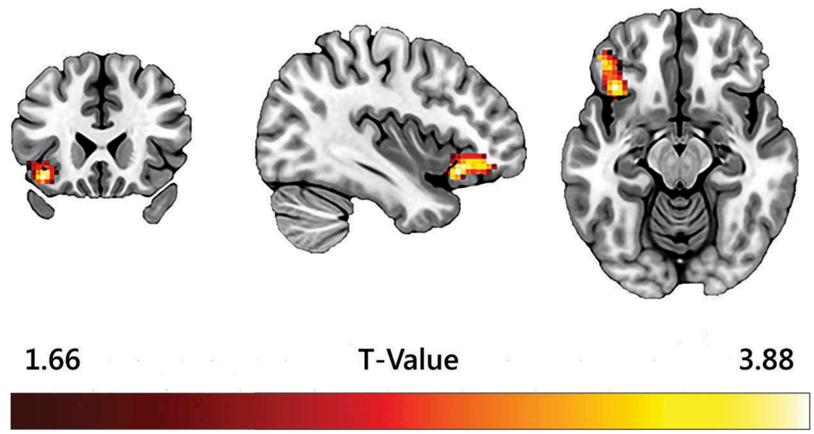

Figure 4. Increased blood oxygen level dependence (BOLD) response activity for the illegal minus legal contrast displayed on coronal, sagittal, and transversal slices using mricrogl.

tangibility, $F(1,33) = 75.80$, $MSE = 0.54$, $p < .001$, $\eta_p^2 = .70$. This was followed up by comparing the difference between illegal hardcopies and legal hardcopies with the difference between illegal softcopies and legal softcopies. A paired samples *t*-test revealed a significant difference between illegal hardcopies and legal hardcopies ($M = 4.76$, $SD = 1.42$) and illegal softcopies and legal softcopies ($M = 2.56$, $SD = 1.72$), $t(33) = 8.74$, $p < .001$.

fMRI data

Obtaining an item illegally (IH+IS) versus legally (LH+LS) led to an increase in activation in the left lateral OFC (−39, 23, −14; extent = 191, Z = 3.30, $p = .039$, Figure 4), while the effect was non-significant for the right OFC. A regression analysis in SPM failed to find a significant correlation ($p > .05$) between the illegal minus legal contrast and the behavioral score (guilty rating: illegal minus legal) in lateral OFC. The left OFC was more active for obtaining a tangible item illegally (IH—LH; −39, 38, −11; extent = 183, Z = 4.08, $p = .001$) but the same contrast was non-significant for an intangible item (IS—LS, $p = .162$). The difference between tangible and intangible ((IH-LH)–(IS-LS)) was significant in left OFC (−39, 38, −11; extent = 116, Z = 3.05, $p = .036$; Figure 5). Whole brain analyses revealed no further significant regions. No other contrasts reached significance.

Relationship between study 2a and 2b

To determine whether reduced activation for intangible theft was associated with a difficulty in representing the intangible items, we conducted a correlation between the activation in the imagery network in Study 2a associated with intangible items and the activation elicited in the lOFC in Study 2b. For this analysis, the average percentage signal change was used across all voxels of the clusters for each participant using MarsBaR (http://marsbar.sourceforge.net). A Pearson's correlation revealed that the more activation (i.e., percent signal change in the imagery network presented in Figure 2) people showed in Study 2a in the intangible compared to the control condition, the larger the difference in lOFC activation (i.e., signal change in the cluster presented in Figure 4) between imagining stealing tangible versus intangible items in Study 2b, $r(34) = .43$, $p = .010$.

General discussion

Despite government funded advertisements against piracy and laws which clearly illustrate the legal ramifications of engaging in illegal downloading, large numbers of people continue to engage in this act. To understand why, the current investigation tested key predictions made by the IPIH (Manesh, 2006), which provides an explanation as to why infringement and theft are dealt with differently in our legal system.

First, the IPIH states that people are more willing to steal intangible than tangible items, regardless of context. In Study 1, we confirmed anecdotal evidence that people are more willing to steal intangible objects. This was the case even when we controlled for the financial cost of the object, the risk of getting caught, the size of the company and the potential financial implications for the organization. This confirms anecdotal evidence that people are more willing to violate moral rules associated with intangible goods compared with tangible.

Second, fMRI Study 2a investigated whether people have more difficulties with representing intangible versus tangible items as predicted by the IPIH. Imagining objects (tangible or intangible) compared with the

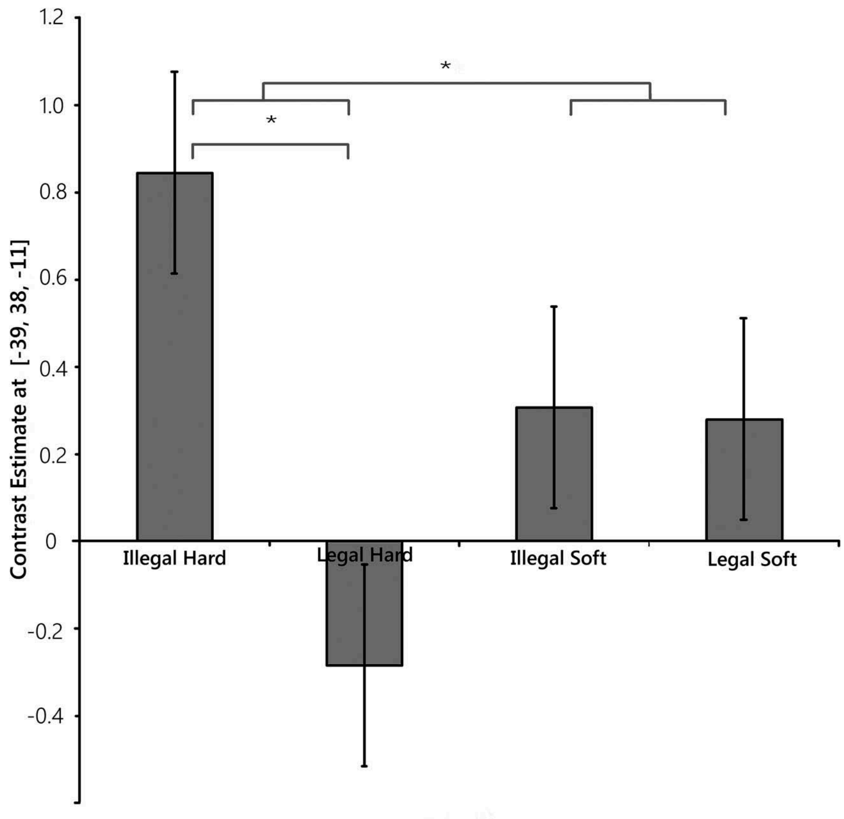

Figure 5. Contrast estimates for the four (IH, LH, IS, and LS) conditions, illustrating significant ($p < .05$) activation differences between IH and LH, as well as the difference between (IH-LH) and (IS-LS), in the left orbitofrontal cortex. Error bars represent standard error.

control condition evoked a mainly left-lateralized network of brain areas often implicated in visual imagery experiments, including the dmPFC, MCC, SMA, left insula, left inferior, and middle frontal gyrus, as well as the posterior superior temporal gyrus and left angular gyrus (Ganis et al., 2004; Guillot et al., 2009; Ishai, Haxby, & Ungerleider, 2002; Turner, Simons, Gilbert, Frith, & Burgess, 2008; Zvyagintsev et al., 2013). These regions coincide with a semantic memory network described by Binder, Desai, Graves, and Conant (2009) who, in their ALE meta-analysis of 120 fMRI studies, identified the dmPFC, left inferior frontal gyrus, and left angular gyrus to be commonly involved in semantic processing. In our study, we used semantic primes to manipulate tangibility, and therefore, it is unsurprising that the imagery network in this task overlaps with the semantic memory network described by Binder and colleagues.

The dmPFC is often involved in self-initiated, self-guided retrieval of semantic information (Binder & Desai, 2011). Therefore, the increased activation in the dmPFC in this study is likely to reflect the retrieval of semantic information when imagining the entertainment titles. Increased activation in the inferior frontal gyrus is probably related to increased demands on verbal working memory (Binder et al., 2009), because semantic neuroimaging studies have reliably shown increased activation in this area when task difficulty increases (Binder, Westbury, McKiernan, Possing, & Medler, 2005; Desai, Conant, Waldron, & Binder, 2006; Sabsevitz, Medler, Seidenberg, & Binder, 2005). Compared with the scrambled word control condition, imagining the entertainment titles increases demands on working memory. Finally, given its unique anatomical proximity to visual, auditory, and somatosensory association areas, the role of the angular gyrus in semantic memory retrieval is probably related with its general role in integrating complex information (Binder et al., 2009). Within the current study, the angular gyrus activity may be indicative of participants retrieving knowledge about the entertainment titles and trying to integrate the multisensory information to help represent those items.

Imaging intangible (versus tangible) items led to more activation within this imaging network, which suggests intangible items are more difficult to represent. The difficulty with imagining intangible information may partly be due to the abstract (i.e., non-physical) nature of imagining something that we cannot interact with physically. According to dual coding theory (Paivio, 1971), abstract words are more difficult to recall than concrete words because we have less physical experience with them and therefore less opportunity for extensive memory consolidation. The increased network for intangible items corresponds with previous neuroimaging studies that have examined comparisons between abstract and concrete events. Lehmann, Pascual-Marqui, Strik, and Koenig (2010) completed a conjunction analysis using source localization data of EEG experiments and revealed a series of regions in the left hemisphere involved with abstract visual representations, these included Brodmann areas 13 (insula cortex) and 47 (inferior frontal gyrus). Using fMRI, Binder et al. (2005) and Sabsevitz et al. (2005) have also shown that the left inferior frontal gyrus is more active for abstract than concrete terms. Our findings are also in line with Hayashi et al. (2014) who found the left inferior parietal lobule and left inferior frontal gyrus to be more active when imagining abstract versus concrete terms.

fMRI Study 2b showed that participants felt guiltier about stealing tangible compared with intangible goods. Thinking about stealing tangible items (compared with obtaining them legally) led to an increase in left lateral OFC activation while this was not the case for intangible items. The OFC has been previously segregated into reward and punishment processing where the medial components are responsible for rewards and the lateral components responsible for punishers (Kringelbach & Rolls, 2004; Molenberghs et al., 2014a). Additionally, the lateral OFC appears to be responsible for processing displeasurable information (Berridge & Kringelbach, 2013) and is associated with increased moral sensitivity (Molenberghs et al., 2014b). The IPIH further postulates that difficulty in representing intangible items leads to less moral sensitivity when stealing these items. The positive correlation between increased activation in the imagery network when imaging intangible items in experiment 2a, and the less relative activation in experiment 2b is in support of this prediction.

A limiting factor of this study is the lack of ecological validity. Specifically, participants had to imagine they were stealing items rather than stealing the items directly. Imagining stealing and actively stealing may not be synonymous with regards to which areas are active. However, previous neuroimaging studies have shown that imagining certain actions and performing those actions rely partially on similar brain regions (Hanakawa et al., 2003; Lotze et al., 1999; Porro, Cettolo, Francescato, & Baraldi, 2000; Roth et al., 1996). We have also shown in the past (Molenberghs et al., 2015) that imagining harming others and feeling guilty about those actions leads to similar activation in lateral OFC as when people harm others directly (Molenberghs et al., 2014a). We have also shown previously that increased feelings of guilt (Molenberghs et al., 2015) are associated with increased lateral OFC activity. The relationship between behavioral guilt score and lateral OFC activation was not significant in the current study; however, this is unsurprising considering the relative small number of participants included in the study. Yarkoni (2009) argues that to have a 66% chance of detecting a moderate correlation between fMRI activity and behavioral regressors, a sample size of at least 50 participants is required.

The data presented here provide a reasonable explanation as to why people are willing to violate moral rules associated with intangible information. By showing increased feelings of guilt and additional activation in lateral OFC for stealing tangible items compared with intangible, it could be argued that we intrinsically place more importance on physical objects. By doing so, we have provided support for the three predictions of the IPIH and provided the necessary groundwork to help explain why people violate moral rules associated with non-physical items more easily.

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